

Memoirs of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. XXV. No. 3.

SOME NEW AMERICAN FOSSIL
CRINOIDS.

BY

FRANK SPRINGER.

WITH SIX PLATES.

CAMBRIDGE, U. S. A.:

Printed for the Museum.

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DURING somewhat protracted researches upon the fossil Crinoids, there have come into my possession a considerable number of specimens belonging to species hitherto undescribed, and also much excellent material illustrative of species imperfectly known, or described without figures. Most of these remain to be dealt with in due course of systematic work. The obligation of describing some specimens of a remarkable new species entrusted to me for that purpose, already too long delayed, tempts me to publish along with it some others which are specially notable, either by way of extending the stratigraphic or geographic range of certain groups, illustrating species hitherto unfigured, or throwing light upon unsettled questions of classification. These objects, which appeal to me with more interest than the mere description of new species, and which I am sure are of greater service to science, have induced the present contribution.

CAMERATA.

DIMEROCRINIDAE.

DIMEROCRINUS Phillips *apud* Murchison.

1836. Silurian System, p. 674, Pl. XVII, figs. 4, 5.

1881. *Dimerocrinus* WACHSMUTH and SPRINGER, Revision of the Palaeocrinoidea, II, 197; III, 101.

1897. *Thysanocrinus* Id. N. Amer. Crin. Cam., 190.

This hitherto exclusively Silurian genus was proposed by Phillips without definition, but upon two species, *D. decadactylus* and *D. icosidactylus*, of which he gave a brief description and figures by which they can be easily recognized as familiar forms at Dudley, England; specimens of them are found in the principal museums, under Phillips's names. From these species the generic characters are readily determinable, but were not correctly understood until

pointed out by Wachsmuth and Springer in 1881, who discovered the infra-basals, not observed by Phillips or other authors before. This made them congeneric with Hall's later *Thysanocrinus*, which we then ranked as a synonym under Phillips's genus (Rev. Pal., II, 198); an arrangement which we afterwards, without good reason, reversed (N. A. Crin. Cam., 190), taking Hall's name, *Thysanocrinus*, for the genus and family. This procedure has been justly criticised, and must be abandoned. Therefore I use the names at the head of this section instead of Thysanocrinidae and *Thysanocrinus*, as adopted in the North American Crinoidea Camerata, and for the same generic type, viz: a Camerate, dicyclic Crinoid, with radials in contact except at the anal side; several ranges of interbrachial plates; biserial arms; and anus without a tube. *Thysanocrinus* and *Glyptaster* clearly go as synonyms. Angelin's *Eucrinus*, which included several species substantially like *D. decadactylus*, was at first sought to be upheld by restricting *Dimerocrinus* to species with only ten simple arms; but the addition of another order of brachials, giving twenty arms simple like the others, seemed such a very slight modification of the same plan of structure, that this distinction was afterwards abandoned, and all the species thrown together under *Dimerocrinus* except the two figured by Angelin as *E. venustus* and *E. minor* (Icon. Crin. Suec., Pl. XV, figs. 5, 7, 16). In these there is a wholly different arm structure, with frequent branching at long intervals, and the arms from the IIBr up, below the axillaries as well as above, biserial, as in *Megistocrinus*, *Abacocrinus*, etc. These, however, appeared from the figures to have the radials separated all around as in the Rhodocrinidae, and for them we proposed the genus *Anthemocrinus*.

What is of especial interest now, however, is that we have the first evidence of persistence of this family type into the Middle Devonian. But for the non-characteristic and somewhat obscure Lower Devonian form described by Jaekel as *Orthocrinus*, the known species of this family have been restricted to the Silurian and earlier. Schultze's "*Rhodocrinus*" *quinquelobus*, which he classed with *Thysanocrinus*, and which we placed under *Eucrinus* (Rev. Pal., II, 197), is monocyclic — a Batocrinoid, as will be shown later. A very distinct specimen from the Hamilton beds near Louisville, with a calyx which cannot be excluded from the family diagnosis, compels us to extend its range accordingly.

DIMEROCRINUS SPINIFERUS, sp. nov.

Plate III, figs. 11a-d.

Calyx elongate with straight sides, truncate above and below like the frustum of an inverted pyramid; rather wider than high, widest just above the arm bases, enlarging from base to arm facets as 1 to 1.8; IBB and lower part of BB included in lower plane. Dimensions of the only specimen: height 17.5 mm.; width at base, 10 mm., at arm bases, 18.5 mm. Base broad and flat; IBB of good size, horizontal, projecting well beyond the column, with tips bending up; BB three times as wide and twice as high as IBB — the largest plates in the calyx — the lower central part produced into spiny nodes, about on a level with the infrabasals; smaller spines form a low ridge leading from these to the middle of the radials. RR a little wider than BB, but only two thirds as high, surmounted by a small spine; followed by two narrow IBr (abnormally three in one ray) one fourth the size of the radials, also spiniferous; and these by one very large, overhanging, spiniferous IIBr at each side, bearing the arm facets; between these a large, wedge-shaped, tumid plate, and above this a pair of further projecting spinous plates overhang the arm facets and mark the widest part of the calyx. First iBr large, followed by two plates, and then two ranges more connecting with others in the tegmen, each bearing a short, central spine; anal area similar, with three plates in the second range, and leading to a subcentral opening in the tegmen. Arm openings two to the ray; facets very small; arms unknown. Tegmen moderately lobed, perfectly flat; all plates bear one or more small spines, the largest being on the posterior oral and the tegmenal axillaries at the margin above the arm bases; oral plates large and well defined. Column facet large and round.

Type. In the author's collection.

Horizon and Locality. Hamilton Group of the Middle Devonian. Charleston, Clark county, Indiana.

The description is rather more of the individual specimen than is desirable, but the unique type is remarkably distinct, and others would probably not show much substantial variation in the characters stated. The spiny ridges and rows passing from basals up the radial series give to the calyx a strikingly angular appearance, unlike that of any other of the genus. From the extremely small size of the facets I suspect there was something peculiar about the arms; but we may not expect to see them, as they are almost never found preserved in the

Crinoids of that prolific locality; they come out from under the overhanging tegmen plates much like those of *Gilbertocrinus*, and were no doubt as small, and not improbably pendent.

BATOCRINIDAE.

DORYCRINUS Roemer.

This case is the reverse of the last. Instead of bringing a Silurian genus forward to the Devonian, we have a species which carries a Carboniferous genus back to that age. The Batocrinidae (*sensu* Wachsmuth and Springer) began in the Ordovician; but *Dorycrinus* and its immediate congeners have been hitherto restricted to the Lower Carboniferous, except for "*Actinocrinus*" *casedayi* Lyon, and some unfigured species by Hall from the New York Hamilton, and the small "*Actinocrinus*" *prumiensis* of Müller, to which must be added for reasons already stated, the "*Rhodocrinus*" *quinelobus* of Schultze. The real spiniferous *Dorycrinus*, until now, has been supposed to begin in the Lower Burlington Limestone; but here is a good one from the Hamilton, at the same locality as the last:—

DORYCRINUS DEVONICUS, sp. nov.

Plate III, figs. 12 a-d, 13.

Calyx elongate, narrowly turbinate to the first axillary, greatly enlarged and deeply lobed above; spreading as from 1 at the base gradually with straight sides to 3 at the axillary IBr, and then suddenly to 5 at the arm bases; narrowly truncate below, and highly arched in the tegmen with deep interbraehial constrictions; tegmen much larger than dorsal cup, and bearing large projecting spines on the interambulacral axillaries. Dimensions of medium sized specimen: height to bottom of arm bases, 12 mm.; total height, 23 mm.; width at base, 4 mm.; at axillary IBr, 12; and at arm bases — the widest part — 21 mm.

Basals forming an erect cup. Radial series elongate, with low median ridge, diminishing in width and branching twice in the calyx, giving 4 arm openings to the ray, facing outward in large projecting lobes; arm openings large and elongate; radial lobes very large, being, from the lower edge of arm facets up, nearly as high as the whole of the dorsal cup below them; a large hollow protuberance stands above each pair of arm bases, and another still larger one

above and between them in the tegmenal axil. Arms unknown. Interbrachial spaces wide, occupied by about 5 ranges of plates, in order 1, 2, 3, etc., in the dorsal cup, and several more above the level of arm bases, between the lobes to a connection with the orals. Anal area similar, with 3 plates in the second range, leading to a subcentral opening in the tegmen, directed up. Tegmen high, low convex on top, broadly curving down interradially between the lobes, which are very high, surmounted by the protuberances already mentioned; these are hollow, composed of small plates, and formed the sockets for large spines, none of which are preserved; tegmen plates very small and numerous; orals not differentiated. Column facet round, filling entire width of base.

Types. Figs. 12a-d are in Walker Museum, University of Chicago. Fig. 13, in author's collection.

Horizon and Locality. Hamilton Group, Middle Devonian. Charleston, Clark county, Indiana.

Besides the two very good specimens figured, I have three others not so complete, but showing the characters of the species with remarkable constancy; the low radial ridge is equally distinct in all. The nearest related form to this that I know is the species from an about equivalent horizon in the Eifel, described by Schultze as *Rhodocrinus quinquelobus* (Mon. Echin. Eifel., 57, Pl. VII), which has a similar narrow, turbinate, elongate calyx, with prominent lobes in the radial regions; but no spines. This species has been the subject of uncertain treatment in systematic literature. Schultze declared its affinities to be with *Thysanocrinus*, as a subgroup within *Rhodocrinus*. Wachsmuth and Springer accordingly placed it under *Eucrinus* on account of its 20 arms. Afterwards, following Schultze's diagram (*loc. cit.*, 57, text-fig. 10), we withdrew it from that group, considering it a Rhodocrinoid (N. A. Crin. Cam., 192); neither of these assignments can stand. The difficulty grows out of the above mentioned diagram, which is wholly incorrect and misleading; how Schultze, careful observer as he usually was, could have constructed it from his specimen, is more than I can understand. The diagram represents a diacyclic Crinoid with radials separated all around by a large interradiial plate; it was based upon a single "ziemlich unvollständigen" and "verdrückte" specimen, in which the posterior side was chiefly exposed, and of which only that view is figured (*loc. cit.*, Pl. VII, 6). This figure shows three large basal plates, each followed alternately by large, somewhat nodose, radials, and these in succession by two primibrachs, the second one axillary and leading to two arm openings; that is, four ranges of plates up to and including the axillary brachials (radials of third

order as then called); there is no sign of infrabasals, and in a slender dorsal eup like that there is no possible room for interradians between the radials. Yet in the diagram there are five infrabasals, large basals, and three orders of radials including the axillary. The description combines the facts of the figure with the errors of the diagram in a singular way, indicating a strange confusion of ideas. Slightly condensed it reads as follows: The "Basalia" (number not stated) form a low funnel, to which circumstance the calyx owes its elongate form (showing that he means the first row of erect plates seen in the figure, and not any invisible plates below, or above, them); the lower part of the six-sided "Parabasalia" project "knopfförmig" (answering precisely the description of the (first) radials in the figure); upon these, wedged into their reentering angles, follow five rays, each of which consists of "drei Radialia," the upper of these axillary (whereas the figure shows beyond a doubt that the lowest of the three radials whose upper plate is the axillary, is the "knopfförmig" plate, resting upon the reentering angles of the "Basalia" which form the "Trichter," and that there is no room for any "Parabasalia" at all); the Interradians, which rest upon the horizontally truncate edge of the "Parabasalia," show a larger Interradial of the first order, etc. (the only possible horizontally truncate plates in the second range are the radials and the anal plate, which the author must have been thinking of when he wrote this).

I have good specimens of an undescribed elongate form substantially the same as Schultze's species, from the Devonian, of Colle, Spain,—a perfectly plain Batoerionid.

INADUNATA.

GASTEROCOMIDAE.

Hitherto no representative of the assemblage of peculiar dieyclic Eifelian genera grouped under this family has been reported in this country, except the species described by Hall under *Myrtillocrinus americanus*. It is now known, however, that there are at least two other genera in our approximately equivalent Middle Devonian that must be referred to it.

The genus *Arachnocrinus* was founded by Meek and Worthen (Geol. Surv. Illinois, II, 177) upon a species which had been described by Hall as *Cyathocrinus bulbosus* (15th Rept. N. Y. St. Cab., 1860, 123) from the Onondaga (= Upper Helderberg = Corniferous) of western New York; this was done chiefly upon

the character of its ponderous arms, and without any accurate knowledge of the structure of its calyx. It was said to have small infrabasals (afterwards stated by Wachsmuth and Springer, *Rev. Pal.*, I, 94, as five), and a single anal plate resting upon the truncated posterior basal; and for these reasons it has always been ranked among the Cyathocrinidae. Wachsmuth and Springer (*Rev. Pal.*, I, 94) described two additional species from the equivalent rocks near Louisville, Kentucky, in one of which they observed a lateral opening directly above the posterior basal, and between two adjoining radials; but this fact attracted no special attention. Nothing was then known of any unusual features of the column or axial opening.

Investigation of the original specimens upon which these several species were described, and of a considerable quantity of additional material since obtained from the typical localities in New York and near Louisville, has disclosed with perfect clearness the characters of the calyx; leading to the interesting result that the remarkable arms of the American species belong to a calyx in no way distinguishable from certain Eifel species described under the name *Gasterocoma*. Some of the New York material above mentioned is in the American Museum of Natural History, including one of the types of *C. bulbosus*, and some in the State Museum at Albany. For the opportunity to use it in this work I am indebted to the courtesy of Prof. R. P. Whitfield, since deceased, and Dr. J. M. Clark, State Palaeontologist. The remainder is in my own collection.

The genus *Gasterocoma* was proposed by Goldfuss (and its synonyms, *Ceramocrinus* and *Epactocrinus*, by Johannes Müller), and afterwards fully described, illustrated and discussed by Schultze (*Mon. Echin. Eifelk.*, 95 *et seq.*), without definite information as to the character of its arms. It belongs to the very peculiar Crinoid fauna characteristic of the Middle Devonian of the Eifel Mountains and adjacent region, which has been so ably studied, and thoroughly described, in the works of Roemer, Müller, and Schultze; and it has not hitherto, to my knowledge, been recognized elsewhere. The leading characters of this genus, and of the little group of peculiar Crinoids associated with it, are, (1) the anus passing out through the dorsal cup below the level of the arm bases; (2) horseshoe-shaped radial facets, with a dorsal canal extending throughout radials and arms; and (3) in most of them an undivided infrabasal disk, usually pierced by a central axial, and four peripheral, canals.

Comparing the calyx of the above mentioned American specimens with this, it now appears that it has an anal opening lateral through the dorsal cup, below the level of the arm bases, between the posterior basal and the two posterior

radials; large, rounded radial facets, directed outwards; a dorsal canal, or dorsal extension of the axial canal, perforating the radials and arms, entirely separate from the ventral or ambulacral groove; undivided infrabasals; and a quadripartite axial opening, consisting of a central canal surrounded by four smaller peripheral ones, extending from the column into the base of the calyx. All of these characters belong equally to *Gasterocomia*; the only point remaining as to which a difference might be noted is the plate above the anal opening. This plate may not be in any way homologous to the anal plate α of other genera, lying, as it does, anterior to the opening, and in front of whatever anal tube may exist. At all events it is wholly inconstant, being present in one Kentucky species, and absent in the other, as well as in the New York species; in both the latter the radials meet above the opening in all specimens where the structures can be distinctly seen. Hall's description of an anal plate touching the basal in *C. bulbosus* is incorrect; the specimen in which he supposed it was (15th Rept. N. Y. St. Cab., Pl. 1, fig. 19) is in poor preservation, the surface much corroded, so that the sutures cannot all be definitely traced; it has an irregular aspect, the space for the infrabasals looks four-sided, and there are possibly only four basals (Pl. II, fig. 3 herein). In none of the other New York specimens, of which we have several much better preserved, is there any such plate as he describes.

Now as to the so-called anal plate, there is the greatest irregularity among the Eifel specimens. Schultze enumerates and figures seven different conditions of this, which he calls the "interradial," in as many specimens, six of them in one species, *G. antiqua* (Mon. Echin. Eifelk., 97, Pl. XII), viz:—

1. The typical form, with a quadrangular plate between the radials and above the opening: Fig. 1.
2. A triangular plate, with the radials closing above it: Fig. 1b.
3. Two plates, of the form and size of No. 1, bisected vertically: Fig. 1a (erroneously marked 1d, being the isolated figure between the second and third rows from the top; there is confusion in the designation of several of the other figures of *G. antiqua* on this Plate: 1g should be f; 1h should be g; 1i should be h; and 1f should be k).
4. Three plates, two smaller ones under the usual large one: Fig. 1d.
5. No plate at all, the posterior basal reaching the tegmen, and the anal opening being under the right posterior radial: Fig. 1e.
6. No plate, the opening directly through the posterior basal, and the radials meeting above it: Fig. 1e.

7. A plate below the opening, between the radials and resting on the posterior basal: Fig. 2.

With such an admitted diversity among specimens in the typical locality, the differences observed among the American species, even granting Hall's doubtful anal plate (which would be the same as case 7 above), there can be no generic distinction based upon this character; and the first impression would be in favor of referring all these species to the European genus. But it will be remembered that the arms of *Gasterocoma* are not known beyond the lowest brachials, which Schultze says (*loc. cit.*, p. 95) are high, with a round cross-section; this agrees with a set of detached arms from the Eifel which I have supposed to belong to this genus, and which are simple, composed of brachials about as wide as long, wholly different from those of *Arachnocrinus*.

That there may be important differences in arm structure among forms of this group having substantially the same calyx, is further indicated by the discovery in the New York Onondaga of another form of this peculiar type, having a similar calyx and axial canal but a totally different arm structure, for which I have proposed the name *Schultzicrinus* (Pl. III, figs. 1-7). Instead of the very heavy, many branching arms of *Arachnocrinus*, with short, deep brachials, it has five simple arms, which are broad and shallow like those of *Synbathocrinus*. The radial facets are directed upward, and fill almost the entire distal face of the radial, which is not usually the case in *Arachnocrinus* and *Gasterocoma*. The position of the radial facets in the latter two genera is very similar, that of *Gasterocoma* seeming to represent a smaller arm. Except for this small difference, which is not very well marked in the specimens, we should not be able, from the calyx alone, to say which of these two thoroughly distinct American forms ought to be referred to *Gasterocoma*. Therefore, until further discoveries, it seems best to let the two genera stand, and add a third.

Another form of somewhat similar habitus and with an undivided base, is *Myrtillocrinus*, which also has the radials perforated by a dorsal canal; but it lacks the laterally opening anus, and in fact it is unknown how the anus is located, as none of the specimens show it. I have refigured the type and another specimen of the American species, *M. americanus* of Hall, for comparison with the other genera (Pl. III, figs. 8a, b, 9). It has a very deep radial facet, indicating that the arms, hitherto unknown, must have been round and heavy. A specimen was figured by Miss E. Wood (Smithson. Misc. Coll., XLVII, 1904, Pl. XVI, figs. 2, 2a) consisting of the calyx with some of the arms and

stems attached, from the same horizon and locality as the above mentioned specimens of *M. americanus*. The calyx, so far as it can be seen, is identical with them; but the axial canal in the stem has three peripheral canals, instead of four, as in the type. Upon this ground alone Miss Wood proposed for it the genus *Tripleurocrinus*, with *T. levis*, as type. Now it is the fact that among the peculiar assemblage of Crinoids belonging to this horizon of the Devonian, having an unusual type of axial canal, there is a wide variation in the form of it, not only within the same genus, but even the same species. In *Cupressocrinus*, for example, it varies from three canals around a central one, to five. This may be seen from Schultze's figures in his Monograph of the Echinoderms of the Eifelkalk, viz:—

<i>C. crassus</i>	Taf. I, figs. 1f, m.....	quadripartite.
<i>C. inflatus</i>	fig. 2b.....	tripartite.
<i>C. hieroglyphicus</i>	fig. 3d.....	tripartite.
<i>C. scaber</i>	fig. 4b.....	quadripartite.
<i>C. abbreviatus</i>	Taf. II, fig. 6a.....	quadripartite.
<i>C. elongatus</i>	Taf. III, fig. 1b.....	quadripartite.
<i>C. gracilis</i>	fig. 2c.....	tri-quadri- and quinquepartite in the same specimen.

Specimens of the same genus in my collection show variations as follows:—

<i>C. gracilis</i>	5 specimens quadripartite; 2 tripartite.
<i>C. inflatus</i>	1 “ “ 7 “
<i>C. sp. undescribed</i>	3 “ “ 4 “

Furthermore, my present material has produced a second quite distinct species, doubtfully referred to *Schultziocrinus*, from the same horizon and locality as the type species, and as *M. americanus* and *T. levis*, having a tripartite axial canal, which cannot be placed in the same genus with the latter. In view of these facts the genus *Tripleurocrinus*, having no other distinctive character than its three peripheral canals, cannot be upheld; and I see nothing in the specimen, which I have figured on Plate III, figs. 10a, b, to distinguish it from *Myrtillocrinus americanus*, of which, however, it furnishes the arm characters, hitherto unknown. They are heavy, as indicated by the facets, apparently simple throughout, and composed of brachials rather shorter than wide.

A fact of no small interest prevailing throughout this group of genera, is the perforation of the radials and arms by a dorsal canal,—a feature which is prevalent in the Recent Crinoids, but not found in many of the Palaeozoic. It was strongly developed among the Devonian Inadunata, appearing in several

other genera. Prof. E. J. Chapman, of Toronto, in 1882 undertook to make this the basis of a general classification of the Crinoids; but it is unavailable among the fossils, owing to the uncertainty of the facts in so many forms.

Another fact to be noted is the frequent presence in these genera with very ponderous arms, of a short first primibrach, often very much shorter than any succeeding ones. This is very marked in *Schultzicrinus*, and also in *Cupressocrinus* and *Petalocrinus*.

The mutual relations of the genera composing this group may be expressed as follows:—

Analysis of the Genera.

Dielytic; base undivided; radials perforate.

Anal opening lateral through dorsal cup

Central axial canal, with 3, 4, or 5 peripherals.

Arms branching more than once. *Arachnocrinus*.

Arm simple, abutting, with long brachials. *Schultzicrinus*.

Arms unknown, probably simple, divergent, and
with short brachials. *Gasterocoma*.

Only 4 arm-bearing radials. *Nanocrinus*.

“ 3 “ “ “ *Scoliocrinus*.

Axial canal simple, without peripherals. *Achradocrinus*.

Anal opening not through dorsal cup

Central axial canal, with 3 or 4 peripherals. *Myrtillocrinus*.

ARACHNOCRINUS Meek and Worthen.

1866. Geol. Surv. Illinois, II, 177.

1879. WACHSMUTH and SPRINGER, Rev. Pal., I, 92.

1896. ZITTEL-EASTMAN, Text-book Pal., 156.

1900. BATHER, LANKESTER'S Treatise on Zool., III, 175.

This genus has never been well illustrated, Hall's figures of *Cyathocrinus bulbosus* being the only ones published, and they entirely failed to show the most important characters of the calyx. The two species described by Wachsmuth and Springer have never been figured at all, save for one non-instructive specimen by Rowley in Greene (Contr. Ind. Pal. XVIII, Pl. LIV, fig. 1). Having the type specimens, and nearly all the others that have been found at the Falls of the Ohio, I am in position to illustrate these species intelligibly; and some newly discovered material, in addition to such of the types as can be found, makes the same possible for the New York species. These are all that are

known referable to the genus. Meek and Worthen's reference to it of Roemer's *Poteriocrinus pisiformis*, from the Silurian of Tennessee, was erroneous, as that species belongs to the Flexible genus *Lecanocrinus*; while *Cyathocrinus granulatus*, referred to it by Wachsmuth and Springer, is a *Gissocrinus*. The statement in the original generic description that there is a lateral anal tube, supported by an anal plate, must fall, in view of what is now known.

Revised Generic Diagnosis.

Calyx small, compared with the relatively heavy arms. Infrabasals undivided. Anus directly through the dorsal cup, below level of arm bases. Radial facets horseshoe-shaped, deep, concave, occupying only part of width of plate, usually directed outward; perforated by dorsal canal passing into the arms. Arms uniserial, branching frequently, with a fairly regular dichotomy. Pinnules absent. Column round.

Genotype. *Arachnocrinus bulbosus* (Hall).

Distribution. Middle Devonian. America.

ARACHNOCRINUS BULBOSUS (Hall).

Plate II, figs. 3-12.

1860. *Cyathocrinus bulbosus* HALL. 15th Rep. N. Y. St. Cab., 123, Pl. I, figs. 19-22.

1866. *Arachnocrinus bulbosus* MEEK and WORTHEN, Geol. Surv. Ill. II, 177.

1879. WACHSMUTH and SPRINGER, Rev. Pal., I, 93.

Type of the genus. A rather small species, with small, globose calyx and ponderous arms; distinguished at once by the great size of its axillary brachials, which are several times as large as the others, extending throughout the rays, giving them a very unusual appearance; average ordinary brachials measure 1 mm. high by 3 wide, while the axillaries next to them are 3 mm. by 4.5. Articulating facet on radials facing obliquely outward. Arms long, cylindrical, with frequent bifurcations, and very little taper to the fourth bifurcation, the farthest preserved. Primibrachs very irregular in number, from 3 to 12; shown by five specimens as follows:—

l. ant.	l. post.	r. post.	r. ant.	ant.
—	9	7 +	6	—
—	3	3	3	—
5	7 +	5	10	12
8	3	4	—	—
—	15	5	3	12 +

The anterior ray probably bifurcates higher than the others, as a rule. Dorsal canal extending throughout the arms (Fig. 12, where it may be seen toward the distal end of the injured arms). Ventral furrow broad, roofed by two interlocking rows of covering plates, about 3 pairs to the ordinary brachial and 9 or 10 pairs to an axillary (Figs. 8 and 9, showing the plates and their sockets). Infrabasal disk small, with obtusely quadrangular column facet, central axial canal, and usually four smaller ones surrounding it. Anus relatively small, and so far as observed not followed by any plate between the radials; Fig. 6a looks as if there might have been one, but this is not certain, as the plates are displaced. Column with highly projecting nodals and long internodes, as well shown by Fig. 5b. Surface smooth.

Horizon and Locality. In rocks of the Onondaga formation, near Le Roy, Livingston county, New York, associated with *Myrtillocrinus* and *Schultziocrinus*; it has not been found outside of that region.

The calyx plates of this species are fairly thick, but it is singular how rare it is to find a specimen showing the structure of the infrabasal disk; Fig. 6b is the only one out of numerous specimens that shows it plain enough to figure. The beautiful specimen figured at 5a, b, on Plate II, is in the New York State Museum at Albany, as is also that of Fig. 7; the former is in a thin piece of free shale, with the calyx and arms in relief on both sides, the stem showing on one. Figs. 4a, b are from an equally characteristic and well preserved specimen in the American Museum of Natural History, New York; Fig. 3, from the same collection, is the only one of Hall's types that can be identified, and it is in poor preservation as to the calyx, and apparently abnormal. The other specimens figured are in my collection, the fruit of two seasons' careful searching of the type region by Mr. Kirk.

ARACHNOCRINUS EXTENSUS Wachsmuth and Springer.

Plate I, figs. 1, 2, 3, 4; Pl. II, figs. 1, 2.

1879. Rev. Pal., I, 93.

A large species, perfectly distinguished from *A. bulbosus* by the absence of any special enlargement of the axillary brachials; all brachials are very short and wide in the lower part of the ray, about 1.5 to 5, deeply rounded but their surface not convex, the axillaries only larger by the slope necessary to start the divisions. Arms thick, round, long, branching three to five times. The rays divide usually on about the third IBr (occasionally one or two less or more),

except the anterior, which uniformly divides much higher up, having 9+, 13, 15, 15, and 19 IBr respectively in five specimens; the halves then bifurcate repeatedly at intervals of from 5 to 20 brachials on a fairly regular plan, with minor variations; the outer branches in each dichotomy continue in a definite direction, while the others branch from them towards the inner side to the number of four or five bifureations; the inner ones mostly branch once or twice, so far as preserved, and probably more. This gives from 20 to 25 ultimate divisions to the ray, or 100 to 125 in all, with the arms still strong and but little tapering. It is probable that five bifureations was the usual limit, as I have a specimen, not figured, with one ray five inches long extending far beyond the fifth and no sign of further branching. There is far more regularity in the arm distribution than in the type species. Radial facets large, occupying the greater part of the distal face of the plates. The calyx plates are rather thin, and are broken and displaced in all the specimens, so their exact form and position cannot be stated, and in all the base is injured beyond recognition. Loose columnals are found, however, in the same beds, showing that the axial canal is quadripartite (Pl. I, fig. 3). Anus small, with no plate between the radials above it; its position is shown in Fig. 2, of Plate I.

This species comes from strata called the Upper Helderberg (= Corniferous = Onondaga) by the collectors at the type locality, the Falls of the Ohio, at Louisville, Kentucky, where it is found only in the *Nucleocrinus* bed below the Hydraulic bed. The type specimen was labeled by Dr. Knapp as from the Hamilton, and so stated in the original description; but this is now known to be erroneous, the exact horizon of all the specimens being definitely fixed as above stated. The type and principal specimens used herein are from the above locality, but some specimens were found in the equivalent rocks in Livingston county, New York, which apparently belong to it. I give figures of two of them (Pl. I, fig. 4; Pl. II, fig. 2), which show the characteristic arm structure, so different from that of *A. bulbosus*, with which they were associated. Fig. 4 shows the anterior ray with about 19 brachials below the bifurcation.

Types. The magnificent specimen figured on Plate I is the type used for the original description, then in the collection of Dr. Knapp, of Louisville, and given to me some years ago together with the type of *A. knappi*, by the late Professor W. W. Borden, who acquired the collection. This specimen seems to have six rays, the extra one being at the right posterior; on account of the broken condition of the calyx we cannot see exactly how they start, but in the space between the right anterior ray and the posterior interradius there must have been two

radials, or else a very large one, axillary, and bearing two rays having upwards of twenty ultimate divisions to each. The other specimens from Louisville, Pl. I, fig. 2, and Pl. II, fig. 1, and two others showing arm structures not figured, were collected by Mr. Geo. K. Greene, from whom I acquired them.

Horizon and Locality. As above stated.

ARACHNOCRINUS KNAPPI Wachsmuth and Springer.

Plate I, figs. 5, 6, 7.

1879. Rev. Pal., I, 93.

A large species, similar to *A. extensus* in the non-differentiation of the axillary brachials (and perhaps only a variant of it), but differing from it in the decidedly greater number of primibrachs in all the rays. It was founded upon a unique specimen, and no others have been discovered; this has four rays preserved to the first, and partly to the second, bifurcation, the right posterior one being lost; these have brachials as follows:—

	l. ant.	l. post.	r. post.	r. ant.	ant.
IBr.	11	14	—	9	14
IIBr.	3-4	—	—	4-4	5

The right anterior ray, by oversight called the right posterior in the original description, is much smaller than the others (as rather poorly shown in Fig. 5, Pl. I), and was evidently recuperated, so the average number of IBr should be taken from the other three, as about 13.

There are enough minor differences to make one think that this great divergence in the condition of the rays, as contrasted with the almost uniform 3 IBr in all but the anterior ray of *A. extensus*, is not merely sporadic. In this particular it is more like *A. bulbosus*, while wholly unlike it otherwise. The primibrachs are short and wide — 1 to 3.6 — and their surface is transversely convex, and depressed at the sutures, so that the arm dorsally resembles a series of interrupted ridges or rings, which is not the case with any of the specimens of *A. extensus*. The radial facets are large, occupying a good part of the plates, and facing obliquely upward. The calyx is well preserved; base concave, with infra-basal disk at the bottom of the fairly large concavity, where details of its condition cannot be seen; basals large, rather tumid, extending well into the cavity. Anal opening very large, considerably excavated into the posterior basal, and succeeded by an elongate triangular plate just reaching to the upper edge of the radials.

This species has a strong resemblance to *Gasterocoma*, especially in the large anal opening, with a plate above it. I have given for comparison one of Schultze's figures of *G. antiqua* with a similar plate above the anus, and others around it, doubtless forming the base of a small anal protuberance.

Type. The type specimen is in the author's collection.

Horizon and Locality. Hamilton Group, Middle Devonian. Stated in the original description to be from Charleston, Clark county, Indiana, on the authority of Dr. Knapp's label; but more probably from the Beargrass quarries, near Louisville.

SCHULTZICRINUS, gen. nov.

An Inadunate, dieyelie Crinoid. Infrabasals coalesce. Anus directly through the dorsal cup, below level of arm bases. Radial facets horseshoe-shaped, concave. Rays perforated by dorsal canal. Arms five, uniserial, simple. Pinnules absent. Column round.

Genotype. *Schultzicrinus typus*, sp. nov.

Distribution. Middle Devonian. America.

The name is given in memory of Ludwig Schultze, whose Monograph of 1866 is by far the richest contribution to the literature of the Devonian Crinoids ever made.

Except for the difference in arms, the above diagnosis would be interchangeable with that of *Arachnocrinus*; this difference is similar to that between *Synbathocrinus* and *Cyathocrinus*. The arms continue directly from the radials without bifurcation, and their component brachials are flat and elongate, instead of round and short. In the fact of not branching they are similar to the arms of *Myrtillocrinus*, but otherwise their structure is very different, and the lack of an anal opening through the cup would distinguish that genus from this at once.

SCHULTZICRINUS TYPUS, sp. nov.

Plate III, figs. 1-6.

Calyx rather small, depressed hemispheric, wider than high; widest at upper angle of basals, contracting above that. Base truncate; infrabasal disk large and distinct; axial canal usually quadripartite, with large central opening and four smaller ones surrounding it. Anus rather large, encroaching on posterior basal; posterior radials meeting above it, without intervening plate, so

far as known. Radial facets shallow, filling almost the entire distal face of the plate, and directed obliquely upward. Arms long and heavy, broadly rounded or almost flat, closely abutting; brachials broad and long, except the first, which is usually very short; ventral furrow broad and shallow, with large covering plates, about five pairs to a plate of average size. Surface smooth. Column large, with very conspicuous nodals about twice the diameter of the internodals, and three or four times as long; there is considerable variation in the length of these plates, as well as the number in the internodes.

Types. In the author's collection.

Horizon and Locality. Onondaga Group of the Middle Devonian. Near Le Roy, Livingston county, New York.

This species and genus are founded upon a series of excellent specimens, eight of them with more or less of column and arms attached, and three more detached cups showing the base and anal opening. They show a remarkable constancy in the characters above stated, and I have figured a thoroughly representative selection from them. It is singular that with all the difficulty in getting at the basal structure of *Arachnocrinus*, it was so readily found in this; the infrabasal disk is larger, and the exterior sutures not so straight. One specimen (Fig. 3, Pl. III) is very much larger than any of the others; the figure is not enlarged, but shows the relative natural size.

SCHULTZICRINUS (?) ELONGATUS, sp. nov.

Plate III, figs. 7a, b, c, d, e.

I have figured under this name a specimen found associated with the foregoing, knowing that it may not belong to this genus. I wanted to give it a name for reference, in hope that future discoveries may throw more light upon it. It has similar broad, upright, closely abutting arms, but they become narrow, deep, and rounded distally (compare Figs. 7e with 1d). Differing from the type species, and all others of this group, the arms distally become strongly ornamented with fine, sharp pustules (Fig. 7c). The cup is of a very different style from that of the others, spreading upward instead of contracting. Unfortunately we have but the one specimen, and a fragment of cup that may be the same; and with so much lacking in this, its real generic characters remain obscure. I doubt if it has the anal opening through the cup. It will be observed that the specimen has a tripartite axial canal in the column; and as this had not been observed in any of the other American forms of this group, except Miss

Wood's "*Tripleurocrinus*," I first thought they might go together; but the type is so different that this seems impossible, and, as already shown, too much importance must not be given to the form of the canal.

Type. Author's collection.

Horizon and Locality. Onondaga Group, Le Roy, Livingston county, New York.

POTERIOCRINIDAE.

The name *Poteriocrinus* has been applied among authors to a very large number of species, whereas the fact is that, as genera are now understood, it belongs to but few. As was the case with most of the genera established by J. S. Miller in 1821, it came later on to be taken as the type of a family, and was numerously subdivided as research became more exact and material more plentiful. This was done especially by Wachsmuth and Springer in the Revision of the Palaeocrinoidea; and the genera then proposed by them, or adopted from others, to be carved out of the parent genus, have for the most part been accepted by subsequent authors as well founded and judicious. The number of recognizable species in *Poteriocrinus* proper was reduced to thirteen, from which probably two, hitherto unfigured, *P. obuncus* White, and *P. whitei* Hall, should be removed; while another *Cyathocrinus macroleurus* Hall, in every way characteristic, from the Lower Burlington Limestone, should be added. The last named species, and another also very characteristic and beautiful species from the Upper Burlington Limestone, *P. doris* Hall, have never been figured. The possession of some excellent specimens for their illustration, and of specimens of another very remarkable species from the Keokuk Group, herein described, has suggested a brief discussion of the genus and its relations.

It has been said with reason that *Poteriocrinus* is not typical of the family group, Poteriocrinidae, to which its name has been applied by Wachsmuth and Springer. The two leading characters which distinguish this family from the other great family of dicyelic Inadunata, the Cyathocrinidae, are:—

1. Pinnulate arms, as against non-pinnulate.
2. A straight and usually wide radial facet, with transverse fuleral ridge, as against a curved and usually narrow facet.

It has been thought that *Poteriocrinus*, along with character No. 1, possessed the radial facet of the Cyathocrinidae. This is only true in part; it is really, as to this character, an intermediate form, its radial facet being small in size, occupying only a part of the distal face of the radial, and therefore more or less round,

but having a fairly well defined and nearly constant transverse ridge. This is distinctly shown in Miller's figures of *P. crassus*, the type species (Nat. Hist. Crin., opp. p. 68, figs. 1A, and 2H to 5H). It also appears clearly in the following illustrations of other early species:—*P. plicatus* Austin, Mon., Pl. IX, fig. 4c; *id.*, de Koninek and Lehon, Crin. Carb. Belg., Pl. I, fig. 11; *P. radiatus*, *Ibid.*, Pl. I, fig. 12. De Koninek's figure 10, of *P. crassus*, shows a very different structure, and the specimen may not belong to the genus.

The same type of articulation obtains in the three species herein illustrated. In all are seen the same deep plication of the calyx plates, which is not a mere surface character, but is due to a folding in the substance of the plates. This, with modification from folds to pits, is a usual, and probably constant character in the genus.

As already stated, one objection to the use of the family name, Poterocrinidae, has been that the genus *Poteriocrinus* is not typical of its family, in not possessing in full the second of the characters above stated as distinguishing it from the largest other Inadunate family, the Cyathocrinidae, viz, a wide, straight radial facet. In discussing this distinction Wachsmuth and Springer (Rev. Pal., III, 189–190) explained that the radials of the Cyathocrinidae have horseshoe-like facets for the brachials; that in the Poterocrinidae they are more or less truncate along the upper margin, and united with the brachials by a transverse ridge, frequently extending their entire width, accompanied by more or less conspicuous fossae for muscles and ligament; the same mode of articulation existing also upon the axillary brachials; that in the rays of the Cyathocrinidae there are, so far as observed, no muscular fossae, neither between radials and brachials, nor upon the axillaries; the apposed faces of all their joints fit closely together, the distal end being slightly concave, the proximal to the same extent convex.

In order to have a basis for some consideration of the possible significance of these two seemingly wide differences in the mode of articulation of the arms, it may be well to give a description of the radial facet as it exists in the living Crinoids. For an accurate statement of this I am indebted to Mr. Austin H. Clark, who has made these articulations the subject of special studies, based both upon his own observations and the work of previous authors:—

Primarily the articular facet in all groups of Recent Crinoids is composed of (1) the dorsal ligament fossa; (2) the transverse ridge; (3) the interarticular ligament fossae; and (4) the paired muscular fossae, these last separated by either an intermuscular ridge or an intermuscular furrow, extending usually

to a rim or elevation about the central canal. In the upper center of the dorsal ligament fossa there is a more or less sudden depression, the ligament pit, just under the transverse ridge, which may be more or less excavated above it. Along the transverse ridge there may be seen a narrow line of transparent, condensed, calcareous matter representing the apex of the fuleral ridge. This is the condition in the young, and generally in adult individuals; but in many species there comes with age an increasing stiffness in the joints; the sculpture of the joint face gradually becomes obsolete or entirely obliterated, and a plane, or more or less curved, union of almost undifferentiated articular faces results. Some of the "Actinometras" have progressed far along these lines. In the obsolescence of the articular faces a curious modification is often seen; with the disappearance of the transverse ridge radial crenellae appear along the dorsal margin of the dorsal ligament fossa, and the transverse ridge, or what remains of it, becomes corrugated, or tuberculated.

In the Crinoids, whenever a union, through old age or otherwise, becomes so close as to preclude motion, these crenellae always begin to form; peripheral at first, they gradually spread inward until they sometimes even reach the central canal, so that, to all appearances they are syzygial; but in young specimens their entirely different aspect can be readily made out. In the genus *Comatula* (Solaris group of P. H. Carpenter) all gradations are seen in the "intercostal" articulation; it may be a typical synarthry; the ligament fossae may become so shallow as to result in a practically flat joint face, without the longitudinal ridge; or crenellae may creep inward so that the joint face appears practically a perfect syzygy. The muscular articulations, as well as the synarthries may undergo a similar transformation.

Thus we see that in the living Crinoids there are a variety of stages, or conditions, as to the structure of these parts, some or all of which may be expected to have become established and run their courses for whole groups, in palaeontological epochs. The fully organized joint face, as above described, represents a generalized type which would tend to persist, like the simple calyx of the Inadunata, from earliest times to the present. The undifferentiated joint face is a highly specialized condition, such as, if established in a given group, would tend to indicate a definite limitation of its geological range, and its early extinction. Recurring to the statement of Wachsmuth and Springer above cited, it will be seen that the two conditions, adolescent and senile, are represented palaeontologically by our two divisions, *Poterioerinidae* and *Cyathoerinidae*.

Much stress has been laid upon this matter of articulation by many authors,

beginning with J. S. Miller, in 1821, who in not very clear terms made it the basis of his general classification of the Crinoidea; and on account of it, at that early day, placed his two genera, *Poteriocrinus* and *Cyathocrinus*, in different grand divisions, Semiarticulata and Inarticulata. With an equal lack of accurate definition it was used by Johannes Müller and von Zittel as the character of the Crinoidea Articulata. It remained for P. H. Carpenter to state the matter clearly when he said (Challenger Report. Stalked Crinoids, 145-6) that "the name-giving difference between the Articulata and the Tessellata is reduced to a supposed difference in the mode of union of the first radials with the joints which they bear."

Of this union there are at least four kinds known among the Crinoids:—

1. Complete movable articulation upon wide, straight facets, filling the distal face of the radials; with fossae, transverse ridge, paired muscles and ligaments: The adolescent type above described, and which would probably be found in the young of all the other types if we had specimens to examine. Example in fossils, *Eupachycrinus* (Pl. IV, fig. 17).

POTERIOCRINIDAE of Wachsmuth and Springer (excepting *Potriocrinus* — an intermediate form).

Cupressocrinus.

All Mesozoic and Recent Crinoids (with the exceptions noted under 3).

Geological range. Ordovician to Present Time.

2. Articulation with fossae, paired muscles and ligaments, but mostly without complete transverse ridge; accompanying loose suture between other plates, producing a flexible calyx admitting much mobility between apposed faces of radials and brachials, whether incorporated by interbrachial plates or not: A modification of No. 1, not very sharply defined. Example in fossils, *Forbesiocrinus*.

NON-PINNULATE FLEXIBILIA, with more or less continuous transverse ridge in some cases, as in *Lecanocrinus*.

Geological range. Restricted to the Palaeozoic; Ordovician to Carboniferous.

3. Articulation upon undifferentiated joint faces, by concavo-convex surfaces, usually without transverse ridge, and with round facets less than width of the radial: The senile condition above described. Example in fossils, *Cyathocrinus* (Pl. IV, fig. 12).

CYATHOCRINIDAE of Wachsmuth and Springer, with a few exceptions.

= Cyathocrinoidea of Bather, plus *Dendrocrinus* and most of its allies, and *Botryocrinus* and its allies.

Also the Non-typical CAMERATA (= Adunata of Bather).

Geological range. Ordovician to Middle of Lower Carboniferous; with a feeble reminiscence in *Lecythiocrinus* of the Upper Coal Measures, and perhaps in *Guettardicrinus* and *Hyocrinus*, and in exceptional cases among the Recent Crinoids.

4. A close, immovable suture, with all articular structures completely obliterated, the rays being rigidly incorporated into the calyx by the growth of solid supplementary plates: A still more highly specialized derivation from No. 1. Example in fossils, *Actinocrinus*.

THE TYPICAL CAMERATA.

Geological range. Limited to the Palaeozoic.

Referring now only to the dieyclic Inadunata, it will be seen that plan No. 1, represents the Poteriocrinidae of Wachsmuth and Springer, including the genus *Poteriocrinus* as a modification in the direction of No. 3, which did not completely attain the senile condition. While it presumably existed from the earliest times, we have not the specimens to demonstrate it clearly for the Ordovician and Silurian. *Cupulocrinus* has wide, straight facets, but may have the articulation of No. 2, as it has other tendencies towards the Flexibilia. *Merocrinus* also has wide facets, but the known specimens do not show how the joint faces are. In fact this plan was for the time completely overshadowed by the specializations of the other three, which held the field with diminishing preponderance while they ran their respective courses to extinction,—Nos. 2 and 4 within the Palaeozoic, and No. 3 practically so. As the others diminished, No. 1 became vigorous, as the dominant plan of the later Palaeozoic, and continued to the present day.

Plan No. 3 represents substantially the Cyathocrinidae of Wachsmuth and Springer, with their usually narrow, horseshoe facets; it appeared in the earliest Ordovician, parallel with those of the Camerata and the Flexibilia; and it ended, as a morphological character of any importance, much before the close of the Palaeozoic. The latest strong genus in which it is known is *Barycrinus*, in the Warsaw; it reappeared in *Lecythiocrinus*, a rare and exceptional form of the Upper Coal Measures; perhaps in *Hypocrinus*, which is little known, even its exact horizon; and in the Mesozoic *Guettardicrinus*, and the Recent *Hyocrinus*; it also tends to appear exceptionally among the Comatulids.

In order to bring the facts of geological succession more clearly before us,

I have prepared the table on the following page showing the occurrence of the genera having these two respective types of articulation,— the inquiry being limited, as before stated, to the dicyelic Inadunata:

Leaving out of consideration the rare *Lecythiocrinus*, the latest Palaeozoic occurrence of the horseshoe facet is in *Barycrinus*, in the Warsaw (possibly St. Louis), where it sometimes shows the remnants of a transverse ridge (Pl. IV, figs. 14, 15, 16). Neither this genus, nor *Cyathocrinus*, nor any other with round facets, has been found in the Kaskaskia, where *Eupachycrinus* and its congeners, with the perfect transverse articulation, flourished in profusion, and from there up into the Upper Coal Measures and Permian.

Such being the general line of succession and order of development, it is not to be expected that here, any more than in the case of other characters relied upon as the basis of large divisions, we shall find any hard and fast boundary line separating the groups represented by plans 1 and 3, neither morphological nor stratigraphic. The two overlapped geologically, and we may expect to find intermediate stages pending the disappearance of the one and the establishment of the other. Thus in *Cyathocrinus*, which began in the Silurian, there are occasional traces of fossae, and of an imperfect, discontinuous ridge; also in *Barycrinus*. But these are irregular, occurring in only a few species; and the facets show no tendency to become straight, but retain the deeply concave, rounded form, for which these genera are so well known. Perhaps the best example of a transition is found in *Poteriocrinus*, in which there seems to have been a struggle to get rid of its specialization; it begins in the Devonian with round facets and a slight trace of a ridge, but in the Carboniferous it has developed a very distinct, straight ridge, within a facet that is still relatively narrow, much less than the width of the radial. When the facet comes to fill the entire distal face of the radial, the form is called *Pachylocrinus* (*olim Scaphiocrinus*) — there being no other material difference between them, unless in the ventral sac. But among the genera in which the complete articulation has become a fixed character there are no exceptions, or tendencies to lose it. When No. 1 was once established, the plan held absolutely, within its own genera and in general, through a long range of geological time, until the present.

In rearranging the genera of the dicyelic Inadunata under a phylogenetic classification, in which morphological considerations were sent to the rear (Lankester Zool., III, 171), Mr. Bather thought that our great divisions into Cyathocrinidae and Poterioerinidae could not meet the needs of the phylogenetist. He therefore established two suborders, Dendrocrinoidea and Cyathocrinoidea,

RADIAL FACETS

	Narrow, round, or less than R.	Wide, straight, equal to R.
RECENT and MESOZOIC	Hyocrinus Guettardierinus, and senile Comatulids	All other Mesozoic and Recent Crinoids
UPPER CARBONIFEROUS	Leeythiocrinus, U. Coal M.; rare. Hypocrinus; exact horizon un- known.	Tribrachiocrinus Lophocrinus Cibolocrinus Erisocrinus Delocrinus Ulocrinus Eupachyocrinus Cromyocrinus Hydreionocrinus Phialocrinus Graphiocrinus Scaphiocrinus
LOWER CARBONIFEROUS	Baryocrinus; remnant of ridge occasionally. Vasocrinus Goniocrinus Atelestocrinus Parisocrinus Cyathocrinus Poteriocrinus; tr. ridge less than R.	Agassizocrinus Stemmatocrinus Eupachyocrinus Zeaocrinus Coeliocrinus Woodocrinus Bursacrinus Pachylocrinus Seytalocrinus Decadocrinus
DEVONIAN	Poteriocrinus Parisocrinus Vasocrinus Maragnierinus Cosmocrinus Rhadinoocrinus Gastrocrinus Scolioocrinus Achradoocrinus Gasterocoma Nanoocrinus Myrtilloocrinus Arachnoocrinus Codiacrinus Botryoocrinus	Seytalocrinus Cupressocrinus; pinnules described, but ? if true pinnules.
SILURIAN	Cyathocrinus; tr. ridge in some Botryoocrinus Gissoocrinus Homocrinus Thenarocrinus Gothocrinus Mastigocrinus Streptocrinus Petalocrinus; short tr. ridge	
ORDOVICIAN	Carabocrinus Palaeocrinus Porocrinus Euspiroocrinus Dendroocrinus Ottawacrinus	Cupulocrinus; no tr. ridge; articula- tion perhaps like Flexibilia. Meroocrinus?; facet wide, but not well known.

All with full transverse ridge.

following "an attempt to sketch the actual race history," which "resulted in the recognition of a distinction between *Dendrocrinus* and its allies, with their broad radial facets and their tegmen on the one hand; and *Cyathocrinus* and its allies, with narrower facets and more solid tegmen, on the other." Of the two suborders he says the "Cyathocrinoidea were the first to be specialized and the first to disappear; while the Dendrocrinoidea moved more slowly and went farther, even to our own day."

In the recognition of two large divisions having these relative periods of development and culmination, we can readily agree; the difference is in the delimitation of the divisions, and the underlying principle upon which it is based, as well as some minor details. Bather's Dendrocrinoidea *Distincta* include what was in our Poteriocrinidae, with the addition of most of the Dendrocrinites and Botryocrinites, which were included in our Cyathocrinidae. In so including them he necessarily minimizes the importance of the mode of articulation upon the radials, which he mentions as one of those characters of which there is "every gradation in the development . . . articulation of plates (being) developed as need arose." He also definitely rejects pinnulation as a character of any value in these large divisions; his Dendrocrinoidea *Distincta* include both pinnulate and non-pinnulate genera, and while his Cyathocrinoidea happen to be all of the latter kind, he says that the presence of pinnules would not remove a genus from that suborder.

As a minor matter, it may be remarked that, judged by the first of the two characters specified by him as distinguishing the suborders, viz, broad radial facets for Dendrocrinoidea, and narrow facets for Cyathocrinoidea, his name for the former is no more happy than that of the Poteriocrinidae has been thought to be; for no genus of Crinoids has relatively narrower facets than *Dendrocrinus* in its typical species, *D. longidactylus*; and on the other hand no genus has broader facets than *Cupressocrinus*, which he includes in the narrow-faceted Cyathocrinoidea.

There is much more to be said in favor of his distinction between the two suborders based upon the character of the tegmen, which certainly represents, in the typical forms, strongly different structures; yet a close analysis would reveal a considerable amount of gradation in its development; and I am not yet convinced that the mode of articulation, while not so conspicuous, is not a character of broader significance than that, from a phylogenetic standpoint, as well as upon morphological grounds.

All the genera with round, or narrow, facets, or lacking a transverse ridge —

waiving *Poteriocrinus* as a transition form — are without pinnules, just as the entire suborder Flexibilia Impinnata is; although there is an occasional tendency, as in *Botryocrinus*, to develop pinnules through ramules with short intervals. But of the genera which established the full straight articulation, every one of them has true pinnules; with doubt as to *Cupressocrinus* of the Devonian — a highly specialized form, more nearly related to some monocyclic genera. And among these we must include *Poteriocrinus*, which was struggling hard to get into the more vigorous group. A couple of other instances of intermediate genera show how strongly these two structures correlate:—Most of the typical Silurian to Carboniferous Cyathocrinidae (non-pinnulate) have the posterior side symmetric, with only a single anal plate; while most of the Poteriocrinidae (pinnulate) have an unsymmetric anal side, with a radianal. Now *Parisocrinus*, although having a *Poteriocrinus* anal side, has the round facets of the Cyathocrinidae;— and with them the pinnuleless arms of that family; whereas *Graphiocrinus*, which has the symmetric *Cyathocrinus* anal side, has the perfect straight facets of the highest developed Poteriocrinidae;— and along with them it has pinnules in abundance. So there must be a powerful association of these two characters to overshadow the third, which is usually a very important one in classification.

It is also an interesting fact in this connection that *Poteriocrinus* has usually very small pinnules, as compared with those of the genera with complete articulation, in some of which — *e. g.* *Decadocrinus* — they become almost large enough to be called ramules. In specimens of *Poteriocrinus* as usually found imbedded in firm limestone, where the matrix has to be worked off with tools, we usually do not see the pinnules at all (see Pl. IV, figs. 1, 2). When the matrix is soft, they can be exposed, *e. g.* Plate VI, fig. 1, where it may be seen how small they are compared with the size of the arm. In Plate V, fig. 2, they appear relatively longer, as is always the case, towards the distal end of the arm. They are finely preserved in the young specimens, figs. 4 and 5, Plate IV, showing their diminutive size even in that stage, when they are usually relatively large. Thus it would seem that the correlation of the two characters, viz, round facets with non-pinnulation, remains in force in case of modification; and that a tendency towards straight articulation by adding a transverse ridge to the round facets is accompanied by a weak pinnulation. This would seem to hold good now; for in Recent Comatulids those with very long pinnules have the most perfectly developed articulations.

Hence it may be stated in general:—

1. Substantially all non-pinnulate dicyelic Inadunata have round facets, less than the width of the radials, and without complete transverse articulation.

2. All pinnulate dicyelic Inadunata (except *Poteriocrinus*) have a well developed and constant transverse articulation, with wide, straight facets the full width of the radials.

3. The first of these groups, being early specialized, was first extinguished, ending, so far as known (save in a feeble reminiscent or sporadic way), before the close of the Lower Carboniferous; while the second persisted to the present time.

4. Much the same thing can be said of the Flexibilia — all being actually or potentially dicyelic — viz:

a. That the non-pinnulate (Flexibilia Impinnata) for the most part, whether with wide facets or narrow, have a specialized articulation, apparently without a complete transverse ridge: The Palaeozoic Flexibilia; while —

b. All pinnulate (Flexibilia Pinnata) have wide and straight facets, with transverse articulation (except *Uintacrinus*, where it is modified by disuse, resulting from the incorporation of brachials by interbrachial plates): Apio-crinidae, Bourgueticrinidae, and the Comatulids.

In view of these facts, I am unable to see any convincing reason for abandoning the arrangement and definition of these two Inadunate families as made by Wachsmuth and Springer. The name *Poteriocrinidae* could be bettered, it is true; but a name is a name in zoölogy, if validly established and its meaning clear, even if not so appropriate as others. The genus *Poteriocrinus*, although not perfectly typical, must by the preponderance of characters remain in the family, and so the family name is not wholly incongruous or misleading, after all.

Whether to treat these two divisions of the Inadunata as suborders, and call them Cyathocrinoidea and Poteriocrinoidea, or simply families as before, is a matter of detail, depending upon the general plan of treatment. What Bather calls suborders and families, may with equal convenience be treated as families and subfamilies; and therefore for the present I prefer to retain the terms as originally employed by us. Accordingly the family definition will be:

Dicyelic Inadunata; pinnulate; with straight muscular
articulation, facets usually filling entire distal face of
radials..... POTERIOCRINIDAE.

Before proceeding with an analysis of the genera in this family, which I set out to give, it is necessary to clear up a few matters of nomenclature that will make more confusion the longer they are ignored.

First, the genus *Scaphiocrinus*, which includes a large number of well known species that have gone under this name for nearly fifty years, and is especially conspicuous in the great collections of several leading museums made from the American Lower Carboniferous during the times of Barris, Wachsmuth, Worthen, Gurley, etc. The changes which I have long known must be made are unfortunate and vexatious, just the sort of overturning of familiar names that I dislike to see; but there is no help for it. The treatment of this name by Wachsmuth and Springer (Revision of the Palaeocrinoidea, I, 112, 121), in connection with *Graphiocrinus*, gave form to an idea which leads to a vast amount of trouble. All the species ranged under it by Meek and Worthen, by Wachsmuth and Springer, and their followers, will have to be referred to some other genus.

Scaphiocrinus was defined by Hall in 1858 (Geol. Iowa, II, 550), with a good diagnosis, a generic diagram, and a species which in a note he expressly declared to be the type, *S. simplex* — a well known species of the Burlington Limestone. All these agree in the following characters: — A single anal plate between the radials; no radianal; 10 unbranched arms (*i. e.*, one bifurcation), with parallel joint sutures. On the assumption, suggested first by Meek and Worthen (Geol. Surv. Illinois, II, 181, 238), that this was identical with de Koninck and Lehon's genus *Graphiocrinus*, we referred Hall's type species, *S. simplex*, to that genus, and then ranged a large number of Poteriocrinoid species under *Scaphiocrinus* as a subgenus — afterwards taken as a full genus — all of which have these characters: — A radianal; arms repeatedly branching, with usually more or less wedge-shaped brachials; — an absolutely distinct generic type. This cannot be done under the rules of nomenclature.

Hall's *Scaphiocrinus* must stand as defined, with *S. simplex* as type, unless held to be a synonym of *Graphiocrinus* de Koninck and Lehon (Rech. Crin. Carb. Belg., 115); and in any event another name must be found for the species placed by us under *Scaphiocrinus*, which form a good generic group.

Graphiocrinus, though described by its authors as having basals only, is a dicyclic Crinoid, and the only difference from Hall's *Scaphiocrinus simplex* is in the supposed position of the anal plate, which is represented in de Koninck's figure as not touching the posterior basal, but resting on the upper corners of the radials, abutting against the first brachials. This is apparently different from the position of this plate in *Scaphiocrinus*, approaching the arrangement in the later Upper Carboniferous genus *Erisocrinus* White, in which the anal α has risen entirely from between the posterior radials, and rests on their distal corners. The plate is, however, partly between the radials in de Koninck's figured speci-

men; and I have now two good specimens of the same species from the typical locality, Tournai, showing the anal side, in which the anal x , while rising high between the first brachials, is also well down between the radials, and rests directly upon the posterior basal. I have figured them both, and there is no doubt about this (Pl. V, figs. 4, 5). The plate is in the same condition as shown in the diagram and figures of Hall's type of *S. simplex* (Geol. Iowa, II, 549, Pl. 9, fig. 10). These specimens are from the Mountain Limestone of Belgium, about equivalent to our Lower Burlington. Now it is significant that in the latter formation there is a species in which, among a number of well preserved specimens, the anal x varies in position from between the radials, resting on the truncate posterior basal, to nearly beyond them, resting only on their corners, as in de Koninck's figure. On such a specimen Meek and Worthen described their *Erisocrinus antiquus*, which, with the other Burlington species described by them, must go out of *Erisocrinus*. In all these, as well as in the other species, including *S. simplex* from the Upper Burlington, the top of the anal plate rises high above the level of the distal face of the radials. There cannot be the slightest doubt that they all fall under *Graphiocrinus*, and for this reason Hall's name *Scaphiocrinus* must be discarded as a synonym.

It is evident that Trautschold's *Phialocrinus* and Miller and Gurley's *Aesiocrinus* are also merely synonyms of *Graphiocrinus*; substantially the same type of anal structure, accompanied by similar unbranched arms, 10 or less in number, with quadrangular brachials, runs under these names successively through the Kinderhook, Burlington, Keokuk, St. Louis, and Kaskaskia, to the Upper Coal Measures. The extreme ventral sac of the Upper Carboniferous form, upon which *Aesiocrinus* was founded, is only an exaggeration of the sac existing in the Kinderhook species, and in the same horizon is found a small species, *G. (Scaphiocrinus) carbonarius* Meek and Worthen, very similar to the latter. It is notable also that in both the Burlington and Upper Coal Measure forms there is a tendency to reduction in the number of arms, from 10 to 9, 7 and 5. The type is a simple and generalized one as to its calyx elements, and therefore long lived.

The situation thus resulting necessitates a name for the species heretofore ranked under *Scaphiocrinus*. Fortunately this can be provided without proposing a new one, simply by reviving the genus *Pachyocrinus*, proposed by Wachsmuth and Springer in 1879 (Rev. Pal., I, 115), and afterwards abandoned by us in Part III, 242, where we, without good reason, referred its species to *Woodocrinus*. The genus was not very clearly defined to start with, but there was a fairly definite assemblage of species, and, what is more important, a

designated type, *Pachylocrinus subaequalis*, described by Hall in 1861 as *Scaphiocrinus aequalis* (Bost. Journ. Nat. Hist., VII, 316). It is one of the most abundant and best known species of the famous Crawfordsville Crinoid beds of the Keokuk Group, and specimens of it are to be seen in almost every museum; and it is a perfectly characteristic example of the type hitherto called *Scaphiocrinus*. It represents all the essential characters of the group defined by us under that name in Revision, I, 112, including what we called *Pachylocrinus*; viz, a *Poteriocrinus* anal side (radial); straight facets occupying the full width of the radials; and pinnulate arms;— to which may be added, from the assemblage of species listed under it, dichotomous arms, branching more than once; brachials uniserial and usually cuneiform; ventral sac strong and club-shaped. Therefore, having a type species, with definite and well known characters, the status of the genus may be accurately fixed.

The genus, with its large number of species, is still rather unwieldy, and may probably be subdivided later, perhaps on the form of the column, which is in some species sharply pentagonal, and in many round. Unfortunately the species named as type for the group called *Scaphiocrinus*, *S. dichotomus* of Hall, is a very inconspicuous one, which has never been figured, and shows only the most general characters; the only character that can be noted to distinguish it from the *Pachylocrinus* group is that of Section *a*, having simple brachials, i. e. only one IBr, as against two or more. It is not my purpose, however, to follow up these finer distinctions; my present interest is to get the names straightened out, so that labels in collections may be corrected.

This leads back to the name of the type species of *Pachylocrinus*, above mentioned, about which there is a curious complication, which may as well be taken up now, as some systematist is sure to do sooner or later. Described by Hall as *Scaphiocrinus aequalis* (*loc. cit.*, 1861), the name was changed by Wachsmuth and Springer (Rev. Pal., I, 116) because of supposed conflict with *Poteriocrinus* (*Scaphiocrinus*) *aequalis* of the same author, described in the Supplement to the Geology of Iowa, 63 (1860). This last species has been listed in the same way — *aequalis* — by S. A. Miller (N. A. Geol. and Pal., 273), and Weller (Bull. 153, U. S. Geol. Surv., 540). But the fact is, that the name of Hall's species in the Iowa Supplement (an entirely different one from that of 1861, being a very conspicuous, large form in the Lower Burlington Limestone) is "*aqualis*," pertaining to water,— a wholly different word from "*aequalis*," equal. Hence the supposed conflict did not exist, and both of Hall's names will have to stand. So the type of this genus must be written *Pachylocrinus aequalis* (Hall); and the

name *subaequalis* of Wachsmuth and Springer will follow *Scaphiocrinus* into the synonymy. As this species is to be found in all the principal collections where Crawfordsville Crinoids have been sent, I suggest to those in charge that they change the label for it to that above indicated. There is a good figure of the species in Hall's photographic Plate V (N. Y. St. Cab. Bull. I, fig. 10, privately distributed); also one of a very mature specimen in Report of the Geological Survey of Illinois, V, Pl. XV, fig. 6. And the two species described by Dr. White in 12th Rept. U. S. Geol. Surv. for 1878 (1880), p. 161-2, Pl. XL, figs. 3a and 4a, as *Scaphiocrinus gurleyi* and *S. gibsoni*, are synonyms of it.

This will also require the removal from *Woodocrinus* of all the species transferred to it by Wachsmuth and Springer from *Pachylocrinus* (Rev. Pal., III, 242); but will leave under that genus provisionally the following American species, mentioned on the same page as transferred from *Zacrinus*, viz:—*Poteriocrinus bursaeformis* White; *Zacrinus elegans* and *Z. ramosus* of Hall; *Z. scobina*, *Z. serratus* and *Z. troostanus* of Meek and Worthen; to which must be added *Z. commaticus* S. A. Miller. All of these are distinguished from *Pachylocrinus* by having quadrangular brachials, and a more heterotomous arm arrangement; which, however, the typical *Woodocrinus* does not possess, and the above named species will probably have to go into a new genus.

With these explanations, intended, as already indicated, only to clear up a few doubtful matters needing adjustment, and not at all as a general discussion of the group, I think the following may be taken as a working basis for a manageable arrangement of the genera composing the family Poteriocrinidae:—

Analysis of the Genera.

Radianal

Radial facets round, not filling face of R.

Rays dichotomous, branching frequently beyond

IIBr. Ventral sac large and long. *Poteriocrinus*.

Radial facets straight, filling face of R.

Rays branching frequently beyond IIBr.

Arms dichotomous

Brachials cuneiform

Ventral sac strong. *Pachylocrinus*.

Brachials quadrangular

Ventral sac not conspicuous. *Woodocrinus*.

Arms heterotomous

- Brachials cuneiform
 - Ventral sac inflated
 - balloon-shaped *Coeliocrinus*.
 - mushroom-shaped *Hydreionocrinus*.
- Brachials quadrangular
 - Ventral sac short
 - RA not touching IBB n. g. *Z. elegans*, etc.
 - RA elongate, usually touch-
ing IBB *Zeacrinus*.
- Rays usually not branching beyond IIBr or IIIBr
 - Arms dichotomous
 - Ventral sac long, rising to height of
arms
 - Arms 10
 - Calyx depressed
 - Sac not forking *Decadocrinus*.
 - Sac forking *Aulocrinus*.
 - Calyx elongate *Scytalocrinus*.
 - Ventral sac inconspicuous or wanting
 - Base not concave; IBB large,
visible
 - Arms 5 or 10
 - Brachials quadrangular
to cuneiform, tending
to biserial *Cromyocrinus*.
 - Anal x above RR *Ulocrinus*.
 - IBB undivided; stem-
less *Agassizocrinus*.
 - Base concave; IBB at bottom of
funnel
 - Arms 10 to 20
 - Brachials quadrangular
to biserial *Eupachyocrinus*.
- No Radial
 - Radial facets straight, filling face of R.
 - Anal x between RR. resting on post. B.
 - Rays branching more than once
 - Arms dichotomous, abutting *Bursacrinus*

- Rays not branching beyond IIBr
 - Brachials quadrangular, uniserial
 - Ventral sac large.....*Graphiocrinus*.
(Synn. *Phialocrinus*, *Aesiocrinus*.)
 - Brachials biserial
 - Ventral sac inconspicuous.....*Delocrinus*.
- No anal x between RR.
 - Brachials biserial
 - Ventral sac inconspicuous or wanting
 - IBB undivided.....*Stemmatocrinus*.
 - IBB small, covered by stem
 - Anal x rests on upper surface
of post. RR.....*Erisocrinus*.
 - No anal x or tube plate visible . . . *Encrinus*.

POTERIOCRINUS J. S. Miller.

1821. A Natural History of the Crinoidea, 65.

1879. WACHSMUTH and SPRINGER, Rev. Pal., 104, where the intervening synonymy is given.

Revised generic Diagnosis.

Inadunate; dicyclie; pinnulate. Articulating facets semicircular, not filling distal face of radials, usually with straight transverse ridge. Radianal obliquely to left of right posterior radial; anal x and first tube plate within dorsal cup. Primibrachs 1 or 2. Arms dichotomous, long, branching frequently. Ventral sac large and long, tapering to the distal end. Calyx plates usually folded into strong plications. Column round.

Genotype. *Poteriocrinus crassus* Miller.

Distribution. Devonian to Lower Carboniferous. Europe and America.

Miller's description of his type species, *P. crassus*, is excellent, even to noting the anal plates, which he did not understand but supposed to be due to irregularity. In spite of all the confusion thrown around it by subsequent authors, his figures give such a fair idea of the strongly plicated plates, and the exact form and construction of the articulating facets, that there should be no hesitation in recognizing the generic type. It is readily identifiable from isolated plates in the Belgian Lower Carboniferous, although, as before observed, the specimen figured by de Koninck and Lehon as *P. crassus* is deformed, and perhaps does not belong to it. The Austins (Mon. Rec. and Foss. Crin., 74) say that Miller's principal figure opposite p. 68 is a restoration made from the original

of their Fig. 3c, Pl. VIII, which, however, it resembles but little. But Miller's species is better characterized by the loose plates he figures; and it is probable that the Austin's *P. plicatus* (Mon., 78, Pl. IX, fig. 4a) is the same thing. Their *P. radiatus* (Mon., Pl. X, figs. 1a, b) is almost indistinguishable in the calyx from my younger specimens figured as *P. doris*, but the arms and ventral sac are so different as to make one wish to see the original specimen before making comparisons; they look much more like those of *Parisocrinus*. *P. spissus* de Koninck and Lehon has nothing in the known parts to distinguish it from Miller's *P. tenuis*.

The genus *Poteriocrinus* has a wide distribution, occurring in the Eifel, Belgium, Britain, and America. It ranges from the Devonian to culmination at the end of the crinoidal formation composed of the Burlington and Keokuk Limestones. It may be represented in the St. Louis by a small species described by Meek and Worthen as *P. hurdianus* (Geol. Surv. Ill., V, 533); the figure is incorrect as to the anal side, and the specimen itself not very clear. The Devonian species described by Schultze, *P. curtus* and *P. stellaris* (syn. *P. angulosus*), are strongly typical of the genus, and Schultze himself remarked the extraordinary resemblance of some of them to British Carboniferous species. The ventral sac, as shown in *P. curtus*, (Mon. Echin. Eifelk., Pl. V, figs. 4a, b), is constructed exactly on the plan of that of *Poteriocrinus* as now understood, and not of *Parisocrinus*, to which it was referred in Revision of the Palaeocrin-oidea, I, 115; the arm shown in the figure is recuperated, and may not have the normal number of brachials. From the calyx alone it is not easy to distinguish between a low form of *Poteriocrinus* and *Vasocrinus*, though I think the radianal, as a rule, is larger in the former; with either the ventral sac or arms preserved the distinction would be clear.

Of the thirteen species ranged under the typical form of the genus by Wach-smuth and Springer, Rev., I, 111, two, never figured, *P. obuncus* White, and *P. whitei* Hall, should be removed, both having wide facets. While adding a remarkable new species to the list, I will first give some much needed illustrations of two other important species, hitherto unfigured.

POTERIOCRINUS MACROPLEURUS (Hall).

Plate IV, figs. 7-11.

1861. *Cyathocrinus macropleurus* HALL, Desc. New Crin., 5; Bost. Journ. Nat. Hist., VII, 295.

1873. *Scaphiocrinus macropleurus* MEEK and WORTHEN, Geol. Surv. Ill., V, 412.

1879. *Vasocrinus macropleurus* WACHSMUTH and SPRINGER, Rev. Pal., I, 96.

Leaving out the recitals of geometrical shape of the various plates — which made up a tiresome and profitless part of the descriptions of that day, their form for the most part necessarily following from the position and office of the plates — and other immaterial details, the essential part of Hall's description is as follows: —

“Body subturbinate to the top of the subradial plates (BB), whence it rises more abruptly to the middle of the first radial plates; abruptly constricted above. First radial plates wider than high, strongly indented above, marked by a medium sized, elevated, subcentral scar for attachment of the arm plates. Surface of plates marked by strong elevations and depressions, forming a series of ridges which originate from the basal plates (IBB), bifurcate on the subradials (BB), and reunite below the scar of the first radial plates; a second set of less strong ridges unites the subradials (BB) across their lateral margins; a third and the strongest set of ridges unites the first radials across their lateral margins. These ridges are formed by the bending or folding of the plates, which are thin, and afford very little substance for their attachment to each other; and this is probably the reason that there are seldom any but detached plates of this species found, while from their frequency it must have been a comparatively abundant species. . . . The separated plates are strongly undulated upon their sides, with a very sinuous margin; these deep sinuosities of the plates in very old specimens show spiculae or bars of calcareous matter extending across the cavity from side to side, thus strengthening the thin joining faces of the plates.”

There is little to add to this description, which might apply equally well to a calyx or detached plate of *P. crassus* from England or Belgium, or *P. plicatus*, as described by the Austins. The arms, if we had them, might show reliable differences, and it is to be noted that the brachials, as shown by two specimens figured, are extremely short; or it may be that the species actually had such a geographical range, with little change. Hall's description was made from specimens from the Lower Burlington Limestone, and it has not been found in the Upper; it is usually found as detached plates, only one entire calyx having been collected there. Loose plates of it are also numerous found in equivalent

strata at Buttonmould Knob, Kentucky. A very good calyx was secured in rocks of the same horizon at Lake Valley, New Mexico, which is not distorted, and gives the relative dimensions better than the types, as follows: —

Height at top of RR.....	22mm.
Greatest width at top of BB.....	31.5
“ “ at top of RR.....	28
Height at top of IBB.....	7.2
Width at top of IBB.....	19
Width at base.....	14

It is therefore a low, spreading calyx, expanding but little to the top of the infrabasals, flaring suddenly and broadly from there to the top of the basals, and thence contracting perceptibly to the distal edge of the radials. The plications in the plates are broad, rounded, and smooth. Radial facets occupying about half the face of the plate, facing obliquely outwards. Primibrachs very short and wide, apparently two or more; one specimen shows two in place, irregular, apparently representing one, with a syzygial distal joint face. Arms unknown, but probably strong, with short and wide brachials.

Types. I have figured the two original types used by Hall. Figs. 7 and 10 were at the time in the collection of Rev. W. H. Barris, now in the Museum of Comparative Zoölogy, Harvard; Fig. 8 was in that of Dr. Otto Thieme, afterwards acquired by me; and the other specimens figured are in my collection.

Horizon and Locality. Lower Burlington Limestone. Burlington, Iowa; Buttonmould Knob, Kentucky; Lake Valley, New Mexico.

POTERIOCRINUS DORIS (Hall).

Plate IV, figs. 1–6.

1861. *Scaphiocrinus doris* Hall, Desc. New Crin., 7; Bost. Journ. Nat. Hist., VII, 312.

1879. *Poteriocrinus doris* WACHSMUTH and SPRINGER, Rev. Pal., I, 111.

Hall's description is substantially as follows: —

“Body narrowly calyculate; base truncate, the sides gently expanding to the top of the first radials. Basal plates (IBB) small, about as wide as high. Subradials (BB) proportionally large, the height one fourth greater than the greatest width. First radial plates much smaller than subradials (BB); second radials (IBr) elongate, and strongly contracted on the sides just above the middle. Arms bifurcating in the ray divisions on the 8th to 10th brachial; brachials below a little longer than wide, contracted in the middle and thickened at the

extremities. Proboscis large and strong, extending at least two and a half inches above the first radial plates. Surface of subradials (BB) each marked by two strong folds extending from the center to the upper sloping margins, those of two adjacent plates meeting corresponding elevations on the two lateral sloping margins of the first radial plates; these, uniting just below the upper truncate margin of the plate, give it a strongly thickened upper edge, upon which the second radial (IBr) rests; less conspicuous folds or elevations mark the other plates; and the entire surface is marked by sharp, slender, radiating striae."

It should be further stated that a similar strong fold to that described on the basals passes horizontally from radial to radial, at the level of the radial facets, giving a well defined, deep, triangular depression where the angles of a basal and two radials meet; the ridge passing downwards from basals to infra-basals spreads out gradually to the lower margin of the latter, where the base is evenly circular; thus the depressions directly below the radials, over the inter-basal sutures, are elongate diamond shaped. The word "radiating," used in describing the slender striae, is misleading; they are parallel, following the large ridges like flutings on a column. Primibrachs 1; radial facets facing nearly vertical.

This is an elongate form, higher than wide, and in this respect in marked contrast with the last species. In a medium sized specimen the height of calyx to greatest width at the bottom of the radial facets is as 1.1 to 1, with a very uniform spread from base of 1 to 3, and above that some contraction to the upper margin of radials. There is a marked difference in these proportions between old and young specimens, the former being more elongate and slender than above stated, while in very mature ones the width will equal, or exceed, the height. This applies to some other characters as well:—In the young the brachials are very elongate and slender, with the dice-box shape strongly in evidence (Pl. IV, figs. 4, 5, 6), while in the older the brachials have filled out until they are as wide as long, and about cylindrical (figs. 1, 2). The actual length of the brachials in Fig. 4 is about the same as in those of Fig. 1 at their longest side; the growth has been in width. This is the rule in the growing Crinoid, as shown in the young Comatulids and other cases, which I have pointed out heretofore.¹ Also the striation along the ridges is much sharper in the young, and obscure in mature specimens like Fig. 1. I have upwards of twenty specimens of this species, in various stages of growth, in which these progressive

¹ *Uintacrinus*. Mem. Mus. Comp. Zool., Vol. XXV, No. 1, p. 63.

variations are thoroughly shown. The small size of the pinnules may be seen in Figs. 4, 5; in the larger specimens they are either broken off, or cannot be shown by cleaning in the hard matrix; only traces of them can be seen in Fig. 1.

The ventral sac is remarkable for its great size and complicated structure. It is built up of longitudinal rows of hexagonal plates similar to the anal plates, with a median elevation connecting from plate to plate, and forming ribs extending the full length of the sac, and converging at the distal end like meridians of longitude. The surface of these plates is completely covered with sharp and deep transverse folds which completely obliterate the sutures, so that their outline cannot be seen. The sac evidently extends beyond the ends of the arms, and tapers to a narrow point, as shown by the imprint in the matrix in Fig. 1. I have not been able to locate the anal opening in any of the specimens; in this group generally it was at the anterior side — the sac representing morphologically a highly developed interbrachial structure extruded through the anus — and from what appears in the next species I think it was near the base of the sac. The column, as usual in the genus, is round, composed of very short, uniform columnals, which increase very slightly in length distally; and there is a very gradual taper at the proximal end.

This species is confined to the Upper Burlington Limestone, and is sharply distinguished from *P. macroleurus* of the Lower by its very long brachials. *P. notabilis*, also from the Lower Burlington, is a similar elongate form, but wholly lacks the striae along the ridges, the best preserved specimens failing to show any trace of them. In surface characters of the calyx it has an extraordinary resemblance to *P. radiatus* of Austin, but the arms and ventral sac of that species, as figured in Mon. Rec. and Foss. Crin., Pl. X, Figs. 1a, b, look more like those of *Parisocrinus*.

Types. The type specimen, formerly in the collection of Dr. C. A. White, cannot be located. The species was exceedingly rare in the early days of collecting at Burlington, but Wachsmuch was quite familiar with the type, and labeled specimens of his own after direct comparison with it. Nearly all of my specimens above mentioned were found long afterwards in two colonies, and from some of these the figures given here are made.

Horizon and Locality. Upper Burlington Limestone. Burlington, Iowa.

POTERIOCRINUS MAGNIVENTRUS, sp. nov.

Pl. V, figs. 1*a*, *b*, 2, 3; VI, figs. 1, 2, 3.

A very large species, length of maximum crown probably ten or twelve inches; height and width of calyx probably about equal, but specimens are all so much flattened that measurements are only approximate. IBB about as wide as long; BB longer, and RR shorter, than wide. Primibrachs usually 2, sometimes 3 or 4, not necessarily in the anterior ray. Calyx plates folded into large ridges distributed as in *P. doris*, with deep triangular and diamond shaped pits intervening; convex part of ridges perfectly smooth, but short, shallow grooves, with tooth-like folds between originating near the margins, pass from plate to plate across the sutures both at the main ridges and in the depressions, giving a finely serrated edge to the plates when exposed. Plates very thin, and meeting by edges as thin as paper, affording little surface for ligaments, which must have had their attachments in the small folds or grooves at the inside. Radial facets oblique, facing more upward than outward. Arms long and heavy, bifurcating more than once with intervals of 12 to 15 plates; composed of short, cuneiform brachials; pinnules small, appearing relatively larger in the distal parts. Ventral sac of enormous size, very wide below, and tapering suddenly toward the distal end of the arms, and then gradually to a small point; it is composed of longitudinal rows of very short, wide plates, with a median ridge or rib, which projects above the folds, and resembles a small arm; these ribs run the full length of the sac, converging at the distal end; there are transverse folds in form of sharply elevated, rounded ridges, one to each plate from opposite sides, with a broad furrow, obliterating all sutures except those between the longitudinal rows of plates, which are faintly visible. Tegmen leading to base of sac anteriorly and laterally composed of a thickly plated skin, connecting with the distal edge of the radials. Column round, composed of very short, alternately projecting columnals.

Types. Yale University Museum; except Fig. 3, Pl. V, and Figs. 2, 3, Pl. VI, which are in the author's collection.

Horizon and Locality. Keokuk Group, Crawfordsville, Indiana.

Several years ago, while visiting Dr. Charles Schuchert at the Yale University Museum, he called my attention to a large crinoidal specimen hanging upon the wall in a frame, being among material collected for Professor Marsh many years before by Mr. Bradley, at the celebrated locality of Corey's Bluff, near Crawfordsville, Indiana. It was at once seen to be a flattened ventral sac

of extraordinary size, belonging to some Crinoid as yet undescribed; and it is the specimen figured herein on Plate V, fig. 2. Looking further through the collections, we found the specimens figured at 1*a*, *b* of the same plate, which showed clearly where the first one belonged. Dr. Schuchert courteously requested me to describe the species, and placed the specimens in my hands for that purpose. My apologies are due him for having delayed its publication until now, owing to press of other work. I have since unearthed, among material quarried for me at Crawfordsville by Frederick Braun, some other specimens which supplement those of the Yale Museum in various particulars.

The size of this remarkable Crinoid is shown in the figures, which are all of natural size; and the ventral sac is developed to a degree of extravagance nowhere else observed. It is a mere enlargement of the structure of *P. doris*, but the ribs due to the median ridge of the plates, instead of being merely indicated by elevation of the folds, have come out from them, and look like arms. But even more striking than the size — which is not confined to one specimen, but seems to be the rule in six specimens out of eight — is the extraordinary fragility of the calcareous structures in so large a Crinoid; there seems to be no surface of apposition between the calyx plates, which thin out to a knife edge at the sutures; the union must have been by long ligamentous bundles attached in folds or fossae back from the edge. This necessarily made an extremely weak and pliant wall, and as a result the specimens, although imbedded in a very soft matrix, are invariably flattened to a thin mass. Allowing for this flattening, the sac in Fig. 2, Pl. V, must have been nearly two inches in diameter. The plates composing the sac are of extreme shortness, being about 1 mm. in length in the median portion of the sac.

I was at first under the impression that the specimens figured as 1 and 2, of Plate V, probably belonged to the same individual; but the presence of the commensally attached *Platyceras* shows that they are not, for the beak of the shell is perfect in Fig. 1, and that part is left intact in Fig. 2, being visible at the lowest corner. Taking the portions of the shell in the two specimens for a guide, I think they are placed in about the same relative positions on the plate that they should have had if belonging together; from the great width between the ribs at the upper edge, it is evident that the sac extended much higher up, and judging by the taper of the upper end, as shown by Fig. 3, it may have been as much longer as the part preserved, thus making the whole crown at least 12 inches high. The *Platyceras* is found attached in nearly all the specimens at about the same height; as its location was for the purpose of feeding upon the

excrements of the Crinoid, this would indicate that the position of the anal opening, in this species and in the genus generally, is near the base of the sac. The distal ends of arms, which are seen pointing downwards, probably curved over where the sac contracted towards the point, leaving its narrow end free, as in Fig. 1, Plate IV.

Further useful details are shown by the figures on Plate VI. Fig. 2 shows the extreme shortness of the brachials in the arm for a long distance up, and also the position of the *Platyteras*, corroborating the estimate of height of the combined specimens on Plate V. This specimen has some extra small plates interposed between infrabasals and the posterior basal, which are abnormal. Fig. 1 shows the small and rapidly tapering lower pinnules, and also the plated skin of the tegmen at the base of the sac. Fig. 3 is a much younger specimen than the others, and shows the greater sharpness and continuity of the striated folds, which here pass to the middle of the plates, as in the young of *P. doris*.

This species might be considered as a tremendously exaggerated *P. doris*; but its short brachials would distinguish it at once, and it has taken on another thoroughly distinctive character in the number of primibrachs, which is here two or more; two is the rule, but three specimens out of five have more, irregularly, in at least one ray.

CYATHOCRINIDAE.

PARISOCCRINUS SUBRAMOSUS (Miller and Gurley).

Plate IV, fig. 18.

1890. *Poteriocrinus subramosus* MILLER and GURLEY, Desc. New Species Echinodermata, p. 49, Pl. X, fig. 1.
 1890. *Poteriocrinus subramosus* MILLER and GURLEY, 16th Rep. Geol. Indiana, p. 365, Pl. X, fig. 1.
 1892. *Poteriocrinus subramosus* S. A. MILLER, N. Amer. Geol. and Pal., First Appendix, p. 681.
 1898. *Poteriocrinus subramosus* Weller, Bibliogr. Index N. Amer. Carbonif. Invertebr., Bull. 153, U. S. Geol. Surv., p. 478.
Syn. Poteriocrinus circumtextus MILLER and GURLEY, Bull. 5, Ill. St. Mus., 31, Pl. 11, figs. 29, 30.

I have figured a very good specimen of this species, in order to direct attention more definitely to its intermediate character between *Poteriocrinus* and *Cyathocrinus*, all of the species referred to it having been described under other names, and authors apparently not being clear as to what it is. Its *Cyathocrinus*-like calyx and arms, and round facets, with its *Poteriocrinus*-like anal structures, are well shown. The ventral sac, which is unusually well preserved in this specimen, is entirely different from that of *Poteriocrinus*, and more of the

Cyathocrinus type, the opening being apparently at the end, as in that genus, and its plates alternating instead of being in longitudinal rows. It is composed of numerous hexagonal plates, which are perforated by pores at the middle of the sides penetrating to the interior, as I illustrated by a number of detailed figures in a paper on pores in the ventral sac in fistulate Crinoids (Amer. Geologist, Sept., 1900, 134-151, Pl. VII), from specimens of this species under the above name. Mr. Bather, commenting on that paper in the November number of the American Geologist for the same year, p. 307, said: "As for the single representative of *Parisocrinus*, referred to *P. subramosus* M. and G., I must confess that I am quite unacquainted with any such species, and that I am unable to find the specific name under any Inadunate genus in the published writings of Miller & Gurley, including Miller's "N. American Geology & Palaeontology" with its appendices." I have pleasure, even at this late day, in supplying him with the references to the literature above cited, where he will find the species, under the Inadunate genus *Potcriocrinus*, described and figured in two different publications of Miller and Gurley in 1890, and listed a third time in 1892 in the first Appendix to Miller's North American Geology and Palaeontology.

The species is from the Keokuk Group at Crawfordsville, Indiana, where it is not uncommon; and Miller and Gurley's *P. circumtextus* was described from an average specimen of it. The specimen figured was found by Mr. Frederick Braun, who has kindly placed it in my hands for investigation.

MARSUPITIDAE.

MARSUPITES J. S. Miller, *ex* Mantell Ms.

1821. Nat. Hist. Crinoidea, 134.

I am now able to make another important addition to the Mesozoic crinoidal fauna of this continent, in the shape of a species of this well known genus. In Europe, both in England and on the continent, it has been found in many places in the Chalk of the Upper Cretaceous, associated with plates of *Uintacrinus*, this fact having been reported frequently in recent years by Bather, Rowe, and others. The most careful search in the Niobrara beds of the American Cretaceous, where *Uintacrinus* is found over a considerable territory, has failed to disclose a trace of *Marsupites* in that formation. The material now in hand was found by Mr. Frederick Braun in the Tombigbee Sandstone of the Upper Cretaceous in northern Mississippi; it consists of one good calyx with a small

part of arms attached, and another fragment, which Mr. Braun has kindly placed at my disposal for investigation.

This is a free floating Crinoid, and, like *Uintacrinus*, has an element in the calyx additional to that usual in the class, viz, a centrale, developed within the ring of infrabasals. In *Uintacrinus*, as I have elsewhere shown, the infrabasals, as well as the centrale, are small and relatively inconspicuous, the infrabasals in somewhat more than half the specimens not appearing at all; but in *Marsupites* these two constitute about one half of the calyx. As to these elements, *Marsupites* is in the same condition morphologically as the dicyclie form of *Uintacrinus*, and in fact this is so as to all the structures up to the arm bases, including the stemless character and the very thin plates. On account of the last two facts the two genera were placed in the same family by H. A. Nicholson and P. H. Carpenter, without knowledge of the still more important similarity in the base. In discussing these relations,¹ I dissented from this view, believing *Marsupites* to be an Inadunate Crinoid, which *Uintacrinus* palpably is not. The new American species, and some specimens from England showing these parts better than I had before seen, lead me to think the interbrachial plates in this genus of more importance than was before supposed. There is certainly more of a definite structure here than is expressed by the term "loose incorporation of brachials"; the interbrachials appear to be very firm plates, connected with the brachials by straight sutures. The union of brachials with radials in *Marsupites* is by straight muscular articulation, though it only occupies part of the distal face of the radial, as in *Poteriocrinus*; in *Uintacrinus* it is doubtless modified by the incorporation of brachials, and consequent loss of motion in the joint, but farther out, where the arms become free, the muscular articulation is resumed. Inadunata with a slight development of true interbrachial structures have now been found in certain Ordovician species, which indicates a close approximation of the two orders, Inadunata and Flexibilia, at a period near their divergence; and it is not unreasonable to suppose that such a condition has recurred in more recent epochs, where the dominating morphological feature was something else. I cannot think the presence in these two genera of a similar new element in the calyx, unknown in other Crinoids, within the ring of infrabasals, whether primarily derived from the stem or not, was a wholly independent development; and for that reason, together with the other general similarities, it seems probable that there was a nearer relation between them than I before supposed. Mr. Austin H. Clark (Proc. Biol. Soc. Washington, XXII, 174,

¹ *Uintacrinus*, Mem. Mus. Comp. Zool., XXV, Pt. I, 53 (1901).

1909), has definitely referred *Marsupites*, along with *Uintacrinus*, to the Comatulida.

As in *Uintacrinus*, the resemblance between the American and European forms is very great, and they may even be of identical species. Not having sufficient wealth of material with which to deduce from the average of many individuals the typical form, and its limits of variation, no satisfactory proof can be made. The differences pointed out are at best but very slight, indicating a minimum of change for so great a geographical dispersion.

MARSUPITES AMERICANUS, sp. nov.

Plate VI, figs. 4a, b; 5.

Calyx globose, wider than high; widest about middle of basals, contracting toward the arm bases. Centrale larger than infrabasals. Dimensions of principal specimen:—Centrale, diameter of pentagon, 18 mm.; IBB, 17 mm. high by 17.5 wide; BB, 18 mm. high by 18 wide; RR, 11 mm. high by 14 wide; radial facets 6 mm. wide. In a large fragment the centrale is 25 mm. wide. Radial facets shallow, facing almost vertically; filling about half the distal face of radial, and having a straight muscular articulation. Primibrachs 2; succeeding brachials to the number of seven in the longest arm preserved wide and very short, with an alternating cuneiform arrangement and an indication of syzygies between Br 3 and 4; ventral groove broad and shallow. A good sized triangular interbrachial plate, having straight sides and apparently joined to the brachials by suture, fills the space between the arm bases. All plates very thin, and covered with moderately fine radiating striae, crossing the sutures and converging at the centers; a strong ridge runs upward from the center of the basals, two meeting at each radial facet. Further structures unknown.

The general outline and surface ornament of this species are not different from what may be seen among specimens of *M. testudinarius* of the English Chalk from Sussex, and other places. These vary from coarse to fine striae, and with such a thin, pliant calyx the contour of the fossil is largely a matter of pressure in its deposition. Measurement of plates shows no substantial difference between the two, an average of five specimens of the English species being as follows:—Centrale, 19.1 mm. wide; IBB, 19.6 mm. high by 19.5 wide; BB, 19.6 mm. high by 20.1 wide; RR, 12.6 mm. high by 15.7 wide; R. facets 8 mm. wide. The only real difference observable in the parts preserved is that in our species the brachials are shorter and wider than in *M. testudinarius*; and if we

had enough specimens with brachials attached to get an average, this might disappear. The calyx figured is smaller than the English species usually appears, but the other fragmentary specimen has plates fully as large as that. The species is rare, and has only been found at the type locality.

Horizon and Locality. In the Tombigbee Sandstones of the Upper Cretaceous. Plymouth Bluff, in northern Mississippi.

EXPLANATION OF THE PLATES.

All figures, unless otherwise indicated by the sign of an improper fraction at the right denoting the degree of enlargement, are natural size; and the specimens, when not otherwise stated, are in the author's collection.

PLATE I.

ARACHNOCRINUS EXTENSUS Wachsmuth and Springer.

Onondaga (Upper Helderberg). Middle Devonian.

- Fig. 1. The type specimen, from the Falls of the Ohio River at Louisville, Ky.; with calyx crushed, but showing the ponderous, multibrachiate arms, and the unequal distribution of IBr, the anterior ray bifurcating much higher than the others; the dorsal canal and small ventral grooves are shown on the cross section of brachials at several places. The specimen apparently has 6 rays.
2. Ventral side of another specimen from same locality, showing anal opening through dorsal cup below RR.
3. Stem ossicle found in same beds and locality, undoubtedly belonging to this species. $\times 2$.
4. Specimen from near LeRoy, Livingston Co., N. Y., probably of this species, dorsal view; arms much displaced, and basal plates partly broken away.

ARACHNOCRINUS KNAPPI Wachsmuth and Springer.

Hamilton Group, Beargrass Creek, Louisville, Ky.

- Fig. 5. The type specimen, posterior view, showing large anal opening between post. B and RR; and the arms to the first bifurcation on the 10th to 14th brachial.
6. Left post. interrarial view of same specimen.
7. Basal view of same, showing margin of undivided IBB, the median part being destroyed.

GASTEROCOMA ANTIQUA Goldfuss.

Middle Devonian. Eifel, Germany.

- Fig. 8. Post. view of calyx, showing anal opening, for comparison with fig. 5. Copy from Schultze, Echin. Eifel, XII, fig. 1b.

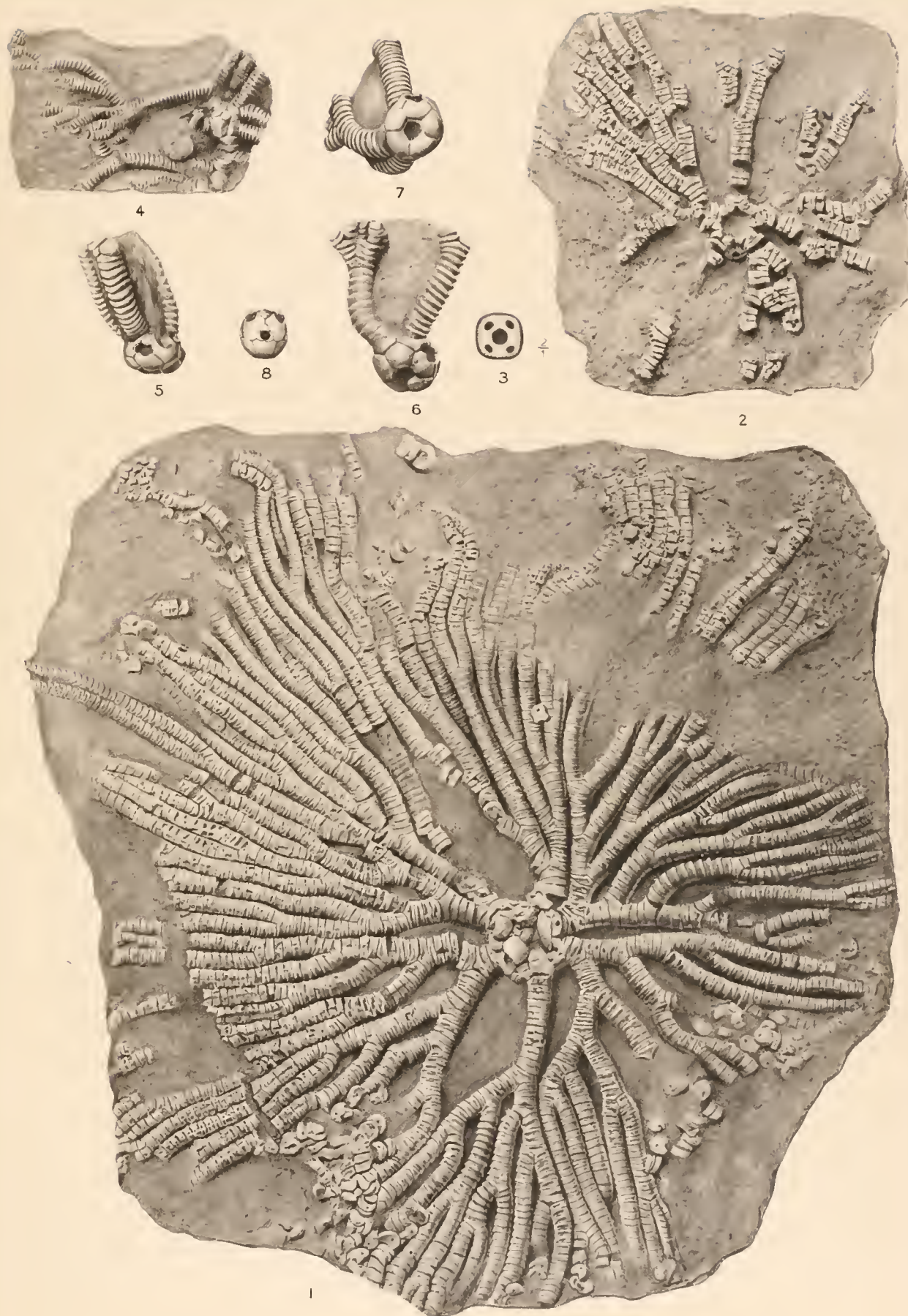


PLATE II.

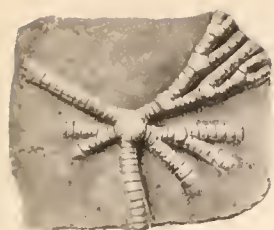
ARACHNOCRINUS EXTENSUS Wachsmuth and Springer.

- Fig. 1. Dorsal view of a third specimen with base broken off, showing branching of anterior and two lateral rays.
2. Small specimen perhaps of this species, from LeRoy, N. Y.

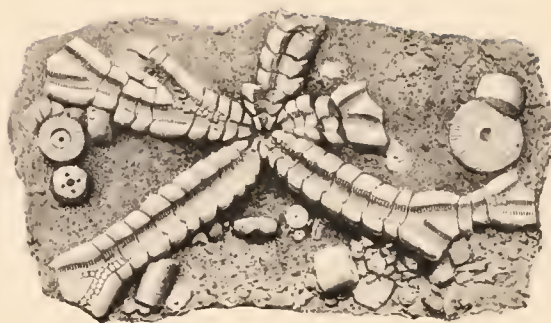
ARACHNOCRINUS BULBOSUS (Hall).

Onondaga Group, Middle Devonian. Livingston Co., N. Y.

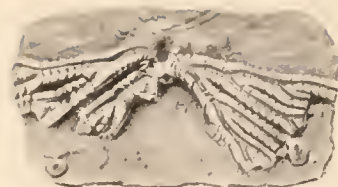
- Fig. 3. One of the types (15th Rept. N. Y. St. Cab., Pl. I, fig. 19); dorsal view, showing arrangement of plates somewhat different from Hall's figure. The surface is much corroded, and sutures difficult to see; there is no such anal plate as originally figured. Amer. Mus. Nat. Hist., New York.
4a, b. R. ant. radial and post. views of another specimen in same collection, showing form of calyx, and great size of axillary brachials; and anal opening between post. B and RR.
5a, b. R. ant. interrarial, and l. post. radial views of a fine specimen in the New York State Museum at Albany; showing the same structures, and the stem with greatly projecting nodals. It lies on a very thin piece of limestone, which has been cleaned away to show both sides of the specimen.
5c, d. Nodal and internodal columnals, showing the central axial canal with 4 smaller peripheral ones; one is the section of stem of 5b, and the other a loose columnal lying with it.
5e. Outline of posterior side of calyx, showing position of anal opening.
6a, b. Posterior and basal views of free calyx, showing undivided IBB pentagon, with quadripartite axial opening; dorsal canal appears double; the hole in r. post. basal in 6b is due to injury.
7. Ventral view of specimen in New York State Museum, Albany, showing anal opening, and ventral furrow in arms.
8. Ventral view of another specimen, in author's collection, enlarged; showing irregular bifurcation of rays, the ventral furrow, and some covering plates in place; orientation uncertain, lower left ray probably the anterior. $\times 2$.
9. An axillary brachial, further enlarged; showing the sockets for covering plates, 8 or 9 at each side. $\times 4$.
10. Dorsal view of small specimen showing irregular bifurcation of rays; orientation uncertain.
11. Similar view of large specimen, showing dorsal canal in several places.
12. Another large specimen, showing ponderous character of arms.



10



8



7



2



9



4b



1



4a



5b



5c



5d



5e



5a



6b



6a



12



3



11

PLATE III.

SCHULTZICRINUS TYPUS, sp. nov.

Onondaga Group, Middle Devonian. Livingston Co., N. Y.

- Fig. 1*a*. Anterior view of specimen with parts of the wide, simple arms, and proximal columnals; the face of a displaced brachial exposing dorsal canal and ventral furrow, and the ventral side of another higher up, showing sockets for covering plates; also joint faces of several detached columnals.
- 1*b*. Posterior view of calyx and base of arms in same specimen; showing anal opening through dorsal cup, with radials meeting above it.
- 1*c, d*. Ventral side of brachial, showing sockets for covering pieces, and end view. $\times 2$.
2. Basal view of calyx of another specimen, showing undivided infrabasal disk, and the quadripartite axial canal; the edge of the anal opening also visible.
3. Basal view of much larger calyx, vertically crushed; showing undivided base and axial opening.
- 4*a*. Lateral view of specimen with part of arms and stem; showing the greatly projecting nodal columnals and thin internodals. Note the very short first IBr in this and the next two specimens.
- 4*b*. An internodal columnal; and 4*c*, a nodal; detached from the same specimen, showing the central and four peripheral canals.
5. Another specimen with stem, showing shorter internodes; and arms with short first IBr; the calyx plates displaced.
6. Another specimen showing extreme disproportion in length of first and second IBr.

SCHULTZICRINUS (?) ELONGATUS, sp. nov.

Onondaga Group, Middle Devonian. Livingston Co., N. Y.

- Fig. 7*a*. Specimen with part of stem and arms, the latter much shattered and displaced, but showing that they were long, and perhaps simple; the broad ventral furrow and deep transverse section of brachials, perforated by dorsal canal, appear at several places.
- 7*b*. Cross section of column, showing tripartite axial canal.
- 7*c, d, e*. Dorsal, ventral, and end views of a higher brachial in same specimen, studded with fine, sharp tubercles; showing the sockets for covering pieces and the dorsal canal. $\times 2$.

MYRTILLOCRINUS AMERICANUS Hall.

Onondaga Group, Middle Devonian. Livingston Co., N. Y.

- Fig. 8*a*. Lateral view of type specimen, showing deep radial facets, with dorsal canal. Amer. Mus. Nat. Hist. New York.
- 8*b*. Basal view of same, showing quadripartite axial canal.
9. A smaller specimen, showing character of stem.

MYRTILLOCRINUS (?) LEVIS (Wood).

Same horizon and locality as last.

- Fig. 10*a*. The specimen described as *Tripleroocrinus levis*, probably of this genus, having a tripartite axial canal; the dorsal canal in radials seems double. U. S. National Museum.
10*b*. Cross section of stem.

DIMEROCRINUS SPINIFERUS, sp. nov.

Hamilton Group, Middle Devonian, Clark Co., Indiana.

- Fig. 11*a*. Posterior view of calyx of only specimen found.
11*b, c, d*. Anterior, basal, and tegmenal views of same.

DORYCRINUS DEVONICUS, sp. nov.

Same horizon and locality as last.

- Fig. 12*a*. Posterior view of calyx, showing sockets of two sets of perforated spines. Mus. University of Chicago.
12*b, c, d*. Anterior, basal, and tegmenal views of same.
13. L. ant. interrarial view of larger specimen.



PLATE IV.

POTERIOCRINUS DORIS (Hall).

Upper Burlington Limestone. Burlington, Iowa.

- Fig. 1. A mature individual, with arms and ventral sac nearly complete, and part of stem, posterior view; the sac tapering rapidly beyond the arms, and terminating in a narrow point, shown by imprint in matrix. Pinnules do not show plainly, being obscured by matrix.
2. Another specimen seen from same side, with ventral sac more sharply preserved; both show the fine subordinate striations passing from plate to plate in the intervals between the larger plications of the calyx.
3. Anterior view of smaller specimen to first brachials only, with sharper and finer folds; showing transverse ridge upon radial facets.
- 4, 5, 6. Three much younger specimens with arms and ventral sac, having relatively longer brachials than the mature specimens, and showing well the small pinnules. These are either the young of the same species as the preceding, or with Fig. 3 belong to a different species morphologically in the younger stage, as indicated by the relatively long and slender brachials. Figs. 4 and 5 are much flattened, otherwise they would appear slender as Fig. 6, which is of about normal width.

POTERIOCRINUS MACROPLEURUS (Hall).

Lower Burlington Limestone, Burlington, Iowa; Lake Valley, New Mexico.

- Fig. 7. One of the types, in the Barris Collection, Mus. Comp. Zool., Harvard; part of large calyx with base wanting. One radial facet is occupied by two very short brachials in succession irregularly; the upper joint face seems to be a syzygy.
8. The other type, calyx of smaller specimen, formerly in collection of Dr. Otto Thieme; showing facets with transverse ridge.
9. Calyx of large specimen from Lake Valley, New Mexico, anterior view; not compressed, and giving the normal contour; a very short IBr in place.
- 10, 11. Detached radials as usually found at Burlington.

CYATHOCRINUS sp.

Knobstone Group, Button mould Knob, Ky.

- Fig. 12. Radial of smooth form, showing undifferentiated, concave, horseshoe shaped articulating facet, without transverse ridge, fossae, or other sculpturing.
13. Radial of highly ornamented species, with relatively smaller facet, showing same structures.

BARYCRINUS TUMIDUS (Hall).

Kcokuk Limestone, Kcokuk, Iowa.

- Fig. 14. Calyx with IBr slightly displaced, showing the concavo-convex apposed faces.

BARYCRINUS sp.

Keokuk Limestone.

- Fig. 15. Radial with concave articulating facet, as in *Cyathocrinus*, and trace of transverse ridge indicated by a low, wrinkled line.
16. Radial with well defined ridge not in a straight line, and interrupted at the middle.

EUPACHYCRINUS QUATUORDECEMBRACHIATUS (Lyon).

Kaskaskia Group. Grayson Co., Ky.

- Fig. 17. Fully differentiated articulating face of radial, full width of plate; a good example of straight muscular articulation. Muscular fossae narrow but distinct; inter-articular ligament fossae broad and deep; a sharply defined intermuscular furrow runs nearly to the transverse ridge, ending in a rounded enlargement perhaps indicating an obsolete dorsal canal; the transverse ridge is low, sharp, narrow; dorsal ligament fossa long and narrow; ligament pit very narrow. $\times 2$.

PARISOOCRINUS SUBRAMOSUS (Miller and Gurley).

Keokuk Group. Crawfordsville, Indiana.

- Fig. 18. Posterior view of a very well preserved specimen, showing full length of ventral sac, composed of hexagonal plates perforated by pores at the middle of the sides: For comparison with *Potriocrinus*, having the same anal structure — radianal — but round, concave articulating facets, and no pinnules.

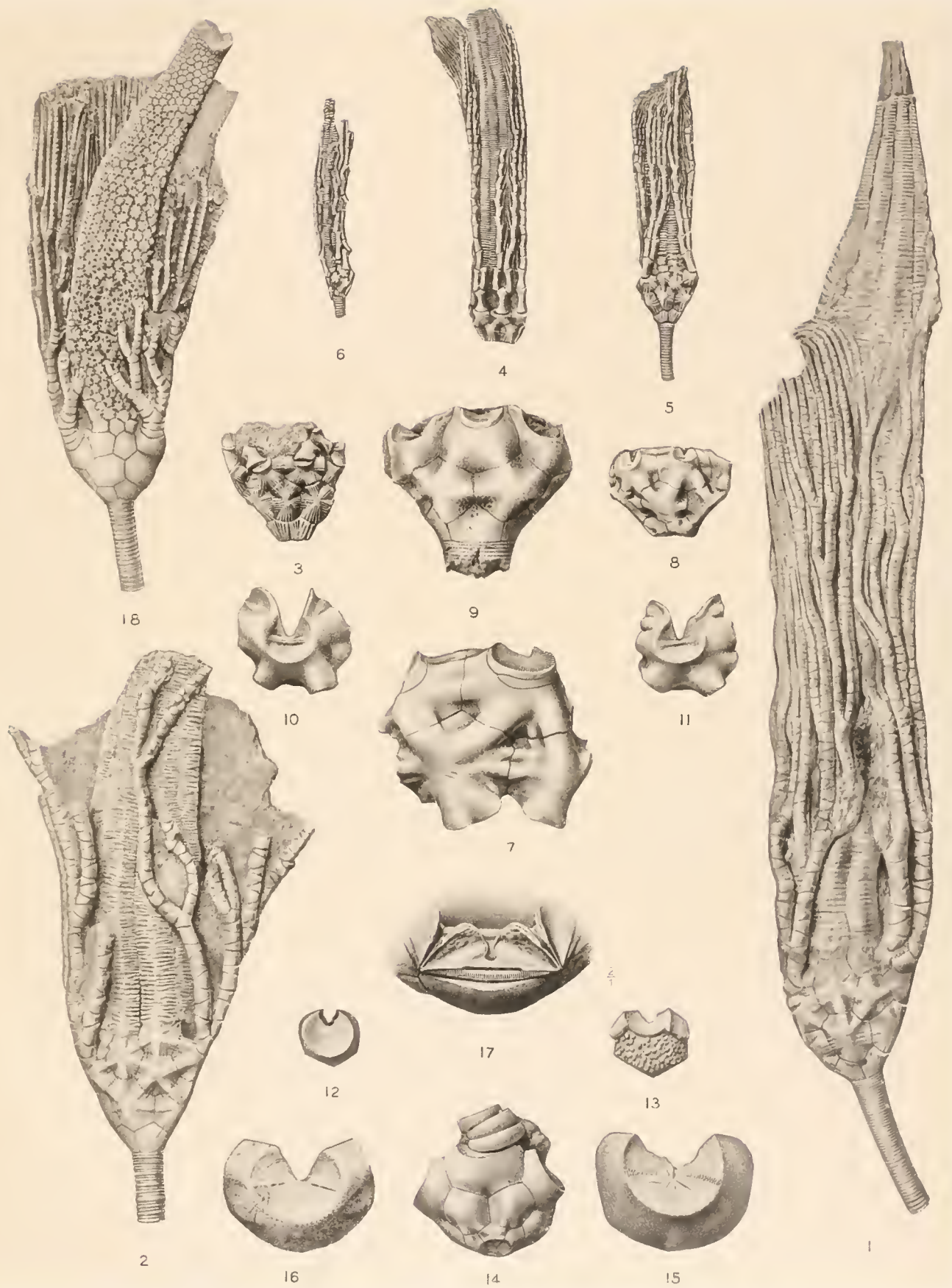


PLATE V.

POTERIOCRINUS MAGNIVENTRUS, sp. nov.

Keokuk Group, Crawfordsville, Indiana.

- Fig. 1a. Posterior view of calyx, with base of arms and origin of ventral sac; showing the longitudinal ribs resembling jointed arms, and transverse folds; part of IBB broken off. Coll. Yale University Museum.
- 1b. Anterior view of same, showing strongly plated integument passing into the ventral sac; a *Platyceras* in commensal attachment, indicating that anal opening was near base of sac, on anterior side.
2. Part of ventral sac of very large specimen, considerably flattened and wider than in life; the beak of a *Platyceras* may be seen at the lower end, showing that top of calyx was a little below that level; some ends of arms are seen curving over at the upper end. Same collection.
3. Distal end of sac of another specimen; apex restored from impression in the matrix, showing how it tapers to a point.

GRAPHIOCRINUS ENCRINOIDES de Koninck and Lehon.

Lower Carboniferous. Tournai, Belgium.

- Fig. 4. A nearly complete crown, posterior view; with anal plate in place, resting upon truncate post. B, and rising above level of RR. $\times 2$.
5. Posterior view of another specimen showing same structures; the anal plate is apparently transversely divided by a faint suture. $\times 2$.

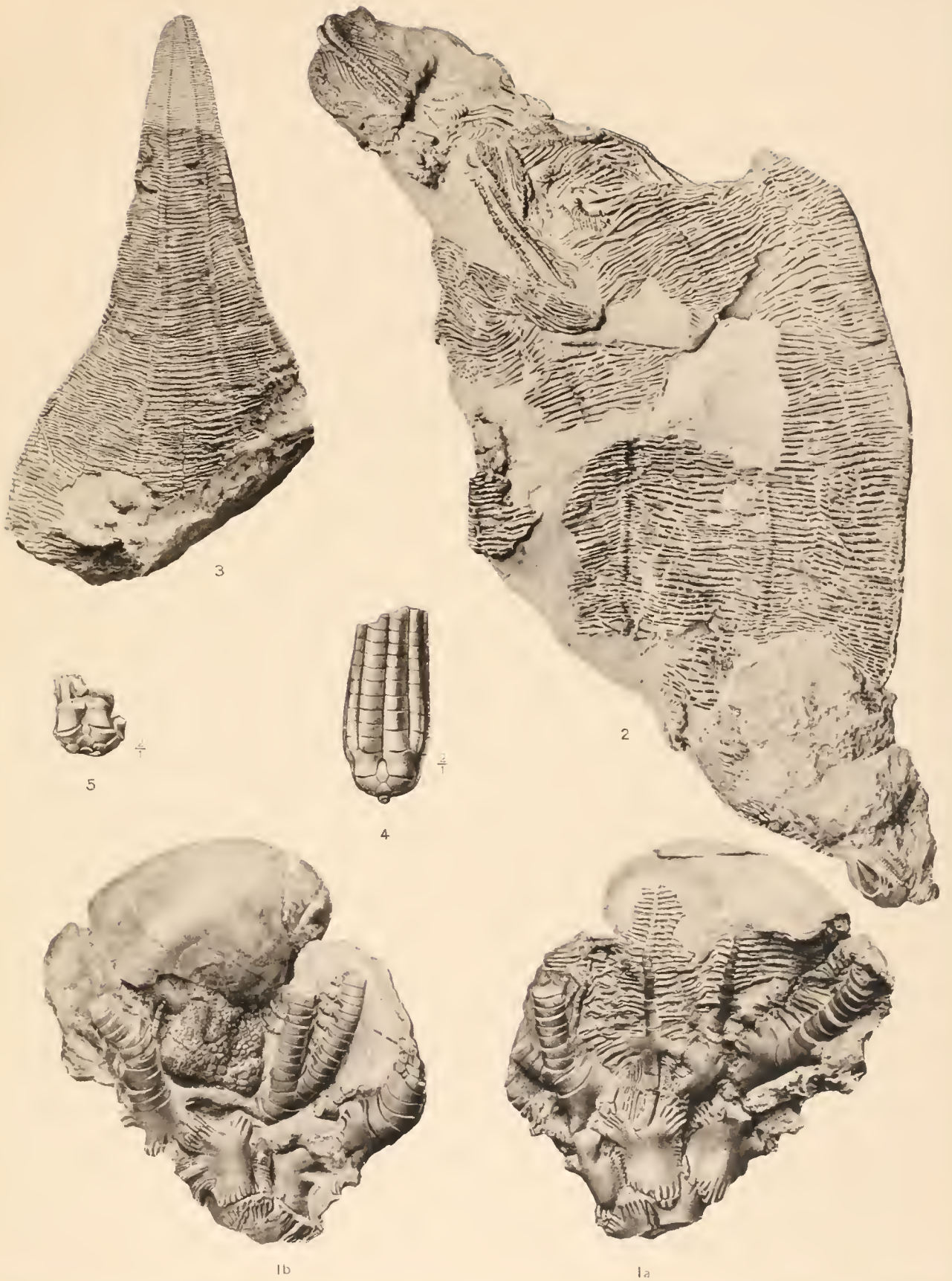


PLATE VI.

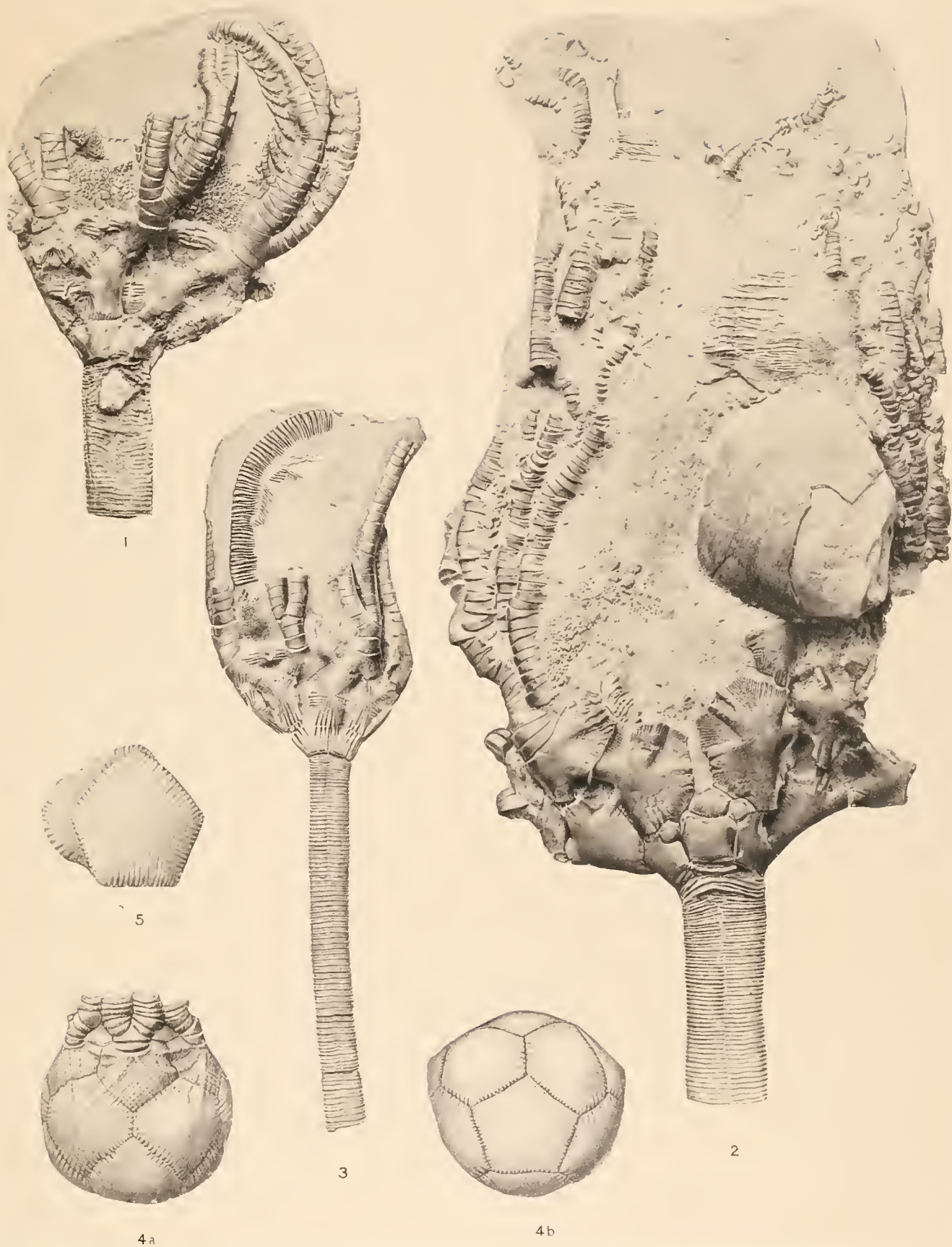
POTERIOCRINUS MAGNIVENTRUS, sp. nov.

- Fig. 1. Lateral view of calyx and lower part of arms, showing the strong, short pinnules, and plated skin of tegmen at base of sac. Coll. Yale University Museum.
2. Left lateral view of mature specimen with stem and arms attached, and remnants of ventral sac towards upper end; *Platyocras* in position with mouth toward anterior side; shows full height of IBB, with abnormally some small plates interposed between them and BB; folds of plates smooth on the raised parts.
3. Young specimen with stem, part of arms, and sac, lateral view. Note the sharp ornamentation of plates on the raised ridges, contrasted with the same parts in last specimen.

MARSUPITES AMERICANUS, sp. nov.

Upper Cretaceous. Plymouth Bluff, Mississippi.

- Fig. 4a. Lateral view of calyx, with bases of arms, and a strong interbrachial passing in between them. Coll. Frederick Braunn.
- 4b. Basal view of same, showing the large centrale within the ring of IBB.
5. An infrabasal plate of a much larger specimen.



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